Biology of the Isopoda of Michigan

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CONTRIBUTION FROM THE BIOLOGICAL STATION AND THE DEPARTMENT OF ZOOLOGY,
UNIVERSITY OF MICHIGAN

[Reprinted from ECOLOGICAL MONOGRAPHS, **17**: 47-79. January, 1947]

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the University of Michigan.

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BIOLOGY OF THE ISOPODA OF MICHIGAN

INTRODUCTION

Although the order Isopoda is a well-known group, scattered over much of the world, and has attracted the attention of many workers, little is known concerning the distribution and life history of most species. Marine isopods have been more thoroughly studied than have the terrestrial and fresh-water representatives. The species of Europe have received considerably more attention than have those of America. In fact, most papers concerned with these crustaceans have been written by European workers, while comparatively few have appeared that dealt with the American fauna. Within the American literature, most contributions have been concerned with taxonomy. Many questions, however, on other aspects of the biology of this group remain to be answered. Because of scarcity of distributional data, limits of the ranges of most North American isopods are still to be determined. Relationships between American and European species have not been clearly established. The ecology and natural history of these animals are fields in which further research is seriously needed.

The literature dealing with the order Isopoda is very extensive. Linnaeus described several species, some of which are still valid today. Thomas Say (1818) was one of the first American systematists to work with these animals. There have been, however, few workers primarily interested in the isopods of this continent. Most of the research on these crustaceans may be classified into three major divisions: taxonomy, morphology, and experimental zoology. Few workers have been concerned with their distribution, ecology and life history.

The objectives of this investigation were to determine: (1) what are the isopods of Michigan; (2) what is their distribution within the state, particularly in the lower peninsula; (3) what are the habitat preferences of the terrestrial species; (4) what are the salient features of the life history of common terrestrial isopods; and (5) what are the variations in sex, size and other biological phenomena to be found by quantitative analyses of an isopod population in nature.

Field study began in the summer of 1938 and continued through August, 1942. Intensive work was done in Washtenaw and adjacent counties in the south, and in Cheboygan and nearby counties in the northern part of the southern peninsula. However, it was not possible to make intensive collections over the entire state. Neither was it feasible to include much of the upper peninsula within the region in which isopods were studied. During the course of this investigation, 359 new locality records for isopods were established from 74 of the 83 counties in Michigan. The remaining nine counties are all located in the upper peninsula, and there are published records from two of them (Adams 1909, Hatch 1939). Fifteen species of isopods are now known to occur in the state. Four of these are reported from Michigan for the first time. There have been few records published for the other species in this state.

I am indebted to numerous persons for their cooperation throughout the investigation, and wish to convey my sincere thanks to each of them. This work was directed by Prof. Frank E. Eggleton, and to him I express gratitude and appreciation for his help and inspiration. Special thanks are also due to Mr. James O. Maloney of the Division of Marine Invertebrates, The United States National Museum, who checked some of the identifications; to the University of Michigan Museum of Zoology and particularly Dr. K. E. Goellner for permission to study specimens from their collections; to Mr. Harry H. Wilcox, Jr., who drew Figures 1-14; to Dr. F. C. Gates for meteorological data; and to the Director for use of facilities at the University of Michigan Biological Station. The collecting trip in the spring of 1942 was financed in part by a Grant-in-Aid from the Horace H. Rackham School of Graduate Studies of the University of Michigan.

DISTRIBUTION OF MICHIGAN ISOPODA

Although the origin and world distribution of the isopods known to occur in Michigan have not been definitely established, certain general statements can be made. As far as is known today, all aquatic isopods of the state are restricted, in general, to the eastern part of North America. Among the terrestrial species, *Ligidium longicaudatum* Stoller and possibly *Trichoniscus demivirgo* Blake probably are to be found only on this continent. The remaining terrestrial species occur in Europe as well as in this hemisphere, and Van Name (1936) states that they may have had their origins in the Old World.

One of the earliest works that dealt with the Isopoda of North America was Say's, "An Account of the Crustacea of the United States" (1818). Richardson's "Monograph on the Isopoda of North America" brought up to date the literature published prior to 1905. Van Name (1936 and supplements 1940, 1942) reviews the taxonomy and distribution of isopods of the entire Western Hemisphere. However, there have been few papers concerned solely with this order from definite sections of this continent—Longnecker (1924) for Iowa, Johansen (1926) and Walker (1927) for Canada, Blake (1931a) for the New England States, and Miller (1938) for California. Although all these regional papers are rather short, nothing even comparable to them has been written for Michigan prior to the present publication.

MICHIGAN RECORDS

Probably the first records of the isopods of Michigan are those in S. I. Smith's "Crustacea of the Fresh-Waters of the United States" (1874). Richardson (1905) added three species to Smith's records, but all her specimens were from Saginaw. Adams (1909) reports *Cylisticus convexus* (De Geer) from Isle Royale. One of the first papers to deal exclusively with the Crustacea of the state was Pearse's "A Preliminary List of the Crustacea of Michigan" (1910), which lists only six species of isopods; many of these had been reported previously by others. However, his paper of 1912 contains the first record of *Asellus intermedius* Forbes for Michigan. Pearse (1913) gives additional records from the state. Hankinson (1916) tells of taking *Mancasellus tenax* (Smith) from Chippewa County. Hatch (1939) records distributional data for six species from Michigan, and Dendy (1944) mentions a new locality for *Asellus communis* Say.

These published accounts of Michigan isopod fauna are the only records known to the author. In all, eleven species have been reported previously from the state. However, the records of these are sparse and in many instances a species has been reported from only one locality. A total of 28 records have been published previously for Michigan.

During this investigation, collections of terrestrial isopods were taken in all counties of the lower peninsula of the state. Two counties were selected in which to do intensive collecting. These were Washtenaw in the southern part of Michigan and Cheboygan at the northern tip of the lower peninsula. The ecology of these two areas is strikingly different. Washtenaw is highly agricultural, is well populated, and has a general loamy soil and deciduous hardwoods; Cheboygan County is generally not agricultural, is sparsely settled, has sandy soil, and its woods are largely aspen or coniferous. Although collections were made in the remaining counties of the lower peninsula, these were not covered as thoroughly as the two mentioned. The records from the upper peninsula are rather meager, since the author's interest did not lie primarily in that region.

Fifteen species of isopods, representing five families and ten genera, have been found in the state of Michigan. Of these 15 species, four are reported for the first time from this state. These are *Armadillidium nasatum* Budde-Lund, *Oniscus asellus* Linnaeus, and *Trichoniscus demivirgo* Blake for the terrestrial species, and *Mancasellus danielsi* Richardson in the aquatic group. With the exception of *Mancasellus dilatus* (Smith), representatives of all these species were collected by the author or were identified by him in the collections of the University of Michigan Museum of Zoology. The following are the species now known for Michigan:

TERRESTRIAL SPECIES

Ligiidae
- *Ligidium longicaudatum* Stoller

Trichoniscidae
- *Trichoniscus demivirgo* Blake

Oniscidae
- *Oniscus asellus* Linnaeus
- *Porcellio scaber* Latreille
- *Porcellio spinicornis* Say
- *Porcellionides pruinosus* (Brandt)
- *Cylisticus convexus* (De Geer)
- *Tracheoniscus rathkei* (Brandt)

Armadillidiidae
- *Armadillidium vulgare* (Latreille)
- *Armadillidium nasatum* Budde-Lund

FRESHWATER SPECIES

Asellidae
- *Asellus communis* Say
- *Asellus intermedius* Forbes
- *Mancasellus tenax* (Smith)
- *Mancasellus dilatus* (Smith)
- *Mancasellus danielsi* Richardson

MICHIGAN SPECIES

The classification used in this paper follows that of Van Name (1936). Although many taxonomic problems exist in this group, the present publication is not concerned with them. As an illustration of such a problem, the differences between the number of articles in the first flagellum of *Asellus communis* and *Asellus intermedius* can be cited. Asellids with anywhere from seven to fifteen articles for each first flagellum are in my Michigan collection. These two species are usually separated from each other on this variable character. This situation will be discussed further in a later section, since it is also thought by some workers that these two species may not be distinct. However, in this publication, following Van Name, they have been treated as different. Many additional uncertainties exist in regard to the other freshwater species.

Inasmuch as the classification of the freshwater species is still not entirely settled, it was decided that it would be better to use characters for aquatic species as they appear in Richardson's monograph rather than to establish, at the present time, new distinguishing characters for use in the following key. Accordingly, the latter part of this key has been adapted from that monograph, making only such changes as were necessary to fit it to the fresh-water isopods of Michigan.

Characters used in the key, for the most part, are those plainly visible in properly preserved specimens. However, tracheae within the pleopods of terrestrial isopods are seen best in living specimens. A solution of nine parts 70% ethyl alcohol, one part glycerine, and a few milliliters of glacial acetic acid is an excellent preservative for isopods. In looking for tubercles and roughness on the body, it may be advisable to dry the specimens. Otherwise the animals should be observed when well covered with preserving fluid. Not all distinguishing characters have been given in the key for each species treated therein, rather, only the more conspicuous ones. For complete descriptions, as well as synonymies, of all isopods of Michigan see Richardson (1905) or Van Name (1936).

KEY TO THE ISOPODA OF MICHIGAN

1. (20) First pair of antennae inconspicuous, rudimentary and not one fourth as long as second pair. Abdominal segments distinct. *Oniscoidea*—Terrestrial Species 2
2. (5) Uropods not extending beyond the terminal abdominal segment. (Fig. 11).....3
3. (4) Small median V-shaped notch in front of head (Fig. 5). *Armadillidium nasatum* Budde-Lund.
4. (3) Head not notched in front. *Armadillidium vulgare* (Latreille).
5. (2) Uropods extending beyond the terminal abdominal segment. (Figs. 6, 12, 13).....6
6. (9) Flagella of second antennae (first are rudimentary) 4 to many articles. (Figs. 7, 8).....7
7. (8) Flagella of second antennae 4 or 5 articles (Fig. 8). Inner branch of uropods shorter or equal to outer branch. Species small (3 mm.). *Trichoniscus demivirgo* Blake.
8. (7) Flagella of second antennae multiarticulate (Fig. 7). Inner branch of uropods longer than outer branch. (Fig. 6). *Ligidium longicaudatum* Stoller.
9. (6) Flagella of second antennae either 2 or 3 articles. (Figs. 9, 10).....10
10. (11) Flagella of second antennae with 3 articles (Fig. 9). *Oniscus asellus* Linnaeus.
11. (10) Flagella of second antennae with 2 articles. (Fig. 10) 12
12. (13) Abdomen abruptly narrower than thorax (Fig. 13). Antennae conspicuously banded with white at joints. *Porcellionides pruinosus* (Brandt).
13. (12) Abdomen not abruptly narrower than thorax (Fig. 12). Banding on antennae absent or not prominent. 14
14. (15) Dorsal surface of body strongly convex; smooth and usually shiny particularly on head. Capable of rolling into a ball. *Cylisticus convexus* (De Geer).
15. (14) Dorsal surface oval rather than convex. Head rough (Fig. 2) or tuberculated (Fig. 4). Cannot roll into a ball.....16
16. (17) Dorsal surface of head rough, but not conspicuously tuberculated (Fig. 2). All pleopods furnished with tracheae. In males, the carpus (third segment from distal end) of seventh pair of legs with a prominent triangular keel-like expansion on dorsal border (Fig. 14). *Tracheoniscus rathkei* (Brandt).
17. (16) Dorsal surface of head with many conspicuous tubercles (Fig. 4). Only first two pairs of pleopods with tracheae. Seventh carpus of male not as above.....18
18. (19) Dorsal surface of body conspicuously tuberculated. Tubercles on head very prominent. At least three color phases: solid dark gray, gray with lighter margins, and variegated. *Porcellio scaber* Latreille.
19. (18) Dorsal surface of body with small inconspicuous tubercles. Color, yellowish with gray-brown patches generally arranged in five longitudinal rows. If living, a double row of bright yellow spots along mid-dorsal line. *Porcellio spinicornis* Say.
20. (1) First pair of antennae plainly visible and at least one fourth as long as second pair. Posterior segments of abdomen fused. *Asellota*—Freshwater species 21

(Adapted from Richardson, 1905)

21. (24) Mandibles with a palp. Lateral margin of head not cleft.....22
22. (23) Flagella of first antennae (the shorter) average 14 articles. No lobe on head behind eyes. *Asellus communis* Say.
23. (22) Flagella of first antennae average 9 articles. Small lateral lobes at base of head just behind eyes (Fig. 1). *Asellus intermedius* Forbes.
24. (21) Mandibles without a palp. Lateral margins of head with a deep conspicuous cleft (Fig. 3)..25
25. (26) Uropods as long as terminal segment of body. *Mancasellus danielsi* Richardson.
26. (25) Uropods shorter than terminal segment of body 27
27. (28) Propodus (second segment from distal end) of first pair of legs with a triangular process. Sides of cleft on lateral margins of head not meeting (Fig. 3). *Mancasellus tenax* (Smith).
28. (27) Propodus of first pair of legs with three acute teeth. Sides of cleft on lateral margins of head sometimes meeting. *Mancasellus dilatus* (Smith).

DISTRIBUTION OF THE SPECIES

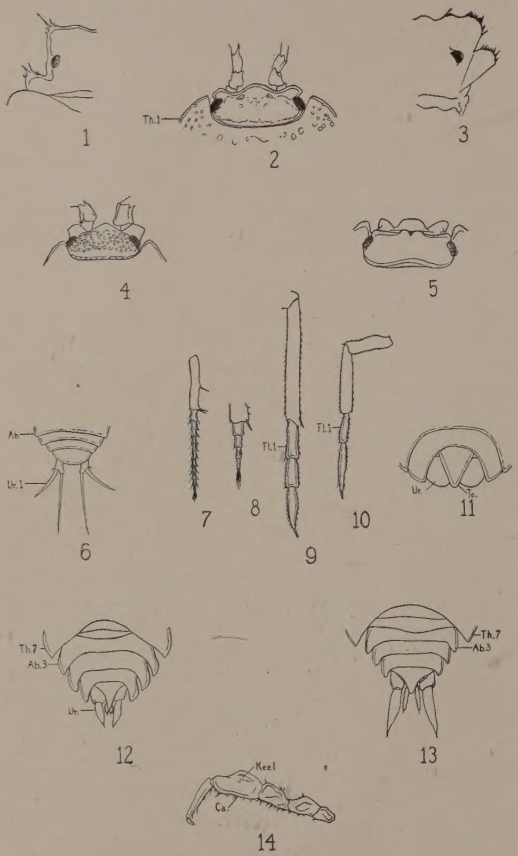
Although the data available on the various species of isopods as they are now known to occur in Michigan are incomplete, certain general statements on the dispersal of these crustaceans within the state can be made at this time. Since each of the terrestrial species has different habitat requirements, their distribution will be discussed from this point of view. Locations of townships from which isopods of the various species have been collected are shown by symbols on the accompanying maps (Figs. 15-18). In many instances a single symbol may stand for several records for a particular species from a township. Check lists for the majority of the species have also been included in order to give more exact information on distribution. These lists (Tables 1-9) include all known records previously published by others, as well as records based on specimens taken during the present investigation, and those unpublished records from the collections of the University of Michigan Museum of Zoology. Where the records are not mine, the references for them are given, while those based on the collections of the University of Michigan Museum of Zoology are indicated by UMMZ.

TERRESTRIAL SPECIES

Ligidium longicaudatum Stoller

As previously stated, *Ligidium longicaudatum* is probably one of the few native terrestrial isopods of North America. Although not extensively collected in Michigan (Fig. 15), all specimens were taken in situations that were protected from flooding, but still always wet. Walker (1927) states that such conditions are essential in its habitat. In Michigan, it has been found only in three southern counties, Berrien, Washtenaw, and Wayne. However, during this investigation very few areas, where the proper conditions existed for the species, were examined. In the University of Michigan Museum of Zoology there are specimens collected under leaves in a wet woodland of Redford Township, Wayne

County. There is a specimen in the United States National Museum collected at Lakeside, Berrien County, but its habitat is not known. Pearse (1910) reported finding this species near the "Overflow," Ann Arbor, Washtenaw County. During the present investigation it was found in abundance among moss in marshlands east of Ann Arbor (T2S-R6E-S36). During the winter of 1940, in this locality, *Ligidium longicaudatum* was very active among the ice crystals under the moss, although the area had been frozen for more than a month.



FIGS. 1-14. Some distinguishing features of various isopods. Fig. 1—Head of *Asellus intermedius* Forbes; Fig. 2—Head of *Tracheoniscus rathkei* (Brandt); Fig. 3—Head of *Mancasellus tenax* (Smith); Fig. 4—Head of *Porcellio scaber* Latreille; Fig. 5—Head of *Armadillidium nasatum* Budde-Lund; Fig. 6—Last abdominal segments and uropods of *Ligidium longicaudatum* Stoller; Fig. 7—Flagellum of second antenna of *Ligidium longicaudatum* Stoller; Fig. 8—Flagellum of second antenna of *Trichaniscus demivirgo* Blake; Fig. 9—Flagellum of second antenna of *Oniscus asellus* Linnaeus; Fig. 10—Flagellum of second antenna of *Cylisticus convexus* (De Geer); Fig. 11—Last abdominal segments and uropods of *Armadillidium nasatum* Budde-Lund; Fig. 12—Posterior portion of *Oniscus asellus* Linnaeus; Fig. 13—Posterior portion of *Porcellionides pruinosus* (Brandt); Fig. 14—Seventh leg of male *Tracheoniscus rathkei* (Brandt). Key to abbreviations: Ab.—Abdomen (number refers to specific segment), Ca.—Carpus, Fl. 1—First article of antenna, Th.—Thorax (numbers refer to specific segments), Te.—Telson, Ur. and Ur. 1—outer branch (expodite) of uropods.

Trichoniscus demivirgo Blake

One of the least known terrestrial isopods of this continent is *Trichoniscus demivirgo*. Inasmuch as it averages only three millimeters in length, it is the smallest of the Michigan species. Its small size and agility may be the chief reasons why it has not been collected as frequently as the other terrestrial isopods. This species occurs in widely scattered areas in the northern part of the United States: from New England (Norton 1909, Blake 1931) as far west as Seattle, Washington (Dailey & Hatch 1940). However, it has not been previously reported for Michigan. In this state it has been found in two localities in the area around Ann Arbor. Both situations were wet spots in open deciduous woods. This isopod was abundant there under stones and

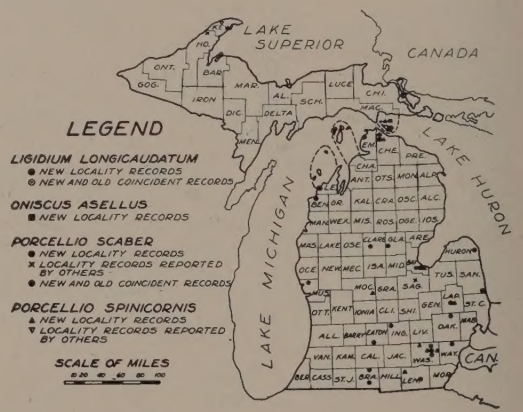


FIG. 15. Distribution within the counties of Michigan of *Ligidium longicaudatum* Stoller, *Oniscus asellus* Linnaeus, *Porcellio scaber* Latreille and *Porcellio spinicornis* Say. Key to abbreviations of county names: Alc.—Alcona; Al.—Alger; All.—Allegan; Alp.—Alpena; Ant.—Antrim; Are.—Arenac; Bar.—Baraga; Barry—Barry; Bay—Bay; Ben.—Benzie; Ber.—Berrien; Bra.—Branch; Cal.—Calhoun; Cass—Cass; Cha.—Charlevoix; Che.—Cheboygan; Chi.—Chippewa; Clare—Clare; Cli.—Clinton; Cra.—Crawford; Delta—Delta; Dic.—Dickinson; Eaton—Eaton; Em.—Emmet; Gen—Genesee; Gla.—Gladwin; Gog.—Gogebic; Gr.—Grand Traverse; Gra.—Gratiot; Hill.—Hillsdale; Ho.—Houghton; Huron—Huron; Ing.—Ingham; Ionia—Ionia; Ios.—Iosco; Iron—Iron; Isa.—Isabella; Jac.—Jackson; Kam.—Kalamazoo; Kal.—Kalkaska; Kent—Kent; Kew.—Keweenaw; Lake—Lake; Lap.—Lapeer; Le.—Leelanau; Len.—Lenawee; Liv.—Livingston; Luce—Luce; Mac.—Mackinac; Mab.—Macomb; Man.—Manistee; Mar.—Marquette; Mas.—Mason; Mec.—Mecosta; Men.—Menominee; Mid.—Midland; Mis.—Missaukee; Mor.—Monroe; Moc.—Montcalm; Mon.—Montmorency; Mus.—Muskegon; New.—Newaygo; Oak.—Oakland; Oce.—Oceana; Oge.—Ogemaw; Ont.—Ontonagon; Ose.—Osceola; Osc.—Oscoda; Ots.—Otsego; Ott.—Ottawa; Pre.—Presque Isle; Ros.—Roscommon; Sag.—Saginaw; St. C.—Saint Clair; St. J.—Saint Joseph; San.—Sanilac; Sch.—Schoolcraft; Shi.—Shiawassee; Tus.—Tuscola; Van.—Van Buren; Was.—Washtenaw; Way.—Wayne; Wex.—Wexford.

decaying leaves. These situations agree rather closely with the description of the habitat by Blake (1931).

Oniscus asellus Linnaeus

Although it has been recorded from the provinces of Ontario and Quebec, Canada (Walker, 1927) and as far west as Rock Island, Illinois (Richardson, 1905), *Oniscus asellus* has not been reported previously from Michigan. In this state it has been collected from widely scattered areas: Ann Arbor, Washtenaw County; Bay City, Bay County; and on Mackinac and Bois Blanc Islands in the Straits of Mackinac (Fig. 15). This isopod was abundant in these localities, all of which were around human settlements. It was found in protected situations which varied from moist to wet.

Porcellio scaber Latreille

This species, which has a rather extensive range in North America, is widespread throughout most of the lower peninsula of Michigan (Fig. 15; Table 1). It has been collected from the southernmost tier of counties to the Straits of Mackinac, and Hatch (1939) reports it from Houghton County in the upper peninsula. Blake (1931a) states that *P. scaber* is a hygrophilous species in New England. To a certain degree, this is also true in Michigan. During the present investigation, it was found along the shores of lakes and rivers (Table 1). Usually, in such habitats, it occurred under logs, boards, straw or drift material. It was more abundant on the outer beaches of lakes than in the other regions along the shores. This is in contrast to *Cylisticus convexus,* which apparently prefers the middle beach.

TABLE 1. Michigan Records of *Porcellio scaber* Latreille.

COUNTY	LOCALITY	LOCUS KEY	REFERENCE
Bay	Bay City	T14N-R5E	
Benzie	Shore Platte Lake	T27N-R15W-S36	
Branch	Shore Coldwater Lake	T7S-R6W-S35	
"	Shore Morrison Lake	T5S-R6W-S32	
Charlevoix	Hog Isl., L. Michigan	- - - -	
"	Pismyre Isl., L. Mich.	- - - -	
Cheboygan	Shore Munro Lake	T37N-R3W-S9	
"	Farm—Hebron Twp.	T38N-R3W-S31	
Clare	Shore Shingle Lake	T18N-R5W-S8	
Eaton	Shore Pine Lake	T1N-R5W-S31	
Emmet	Shore Lake Michigan	T38N-R6W-S34	
Gladwin	Gladwin St. Park	T18N-R2W-S1	
Houghton (UP)	Calumet		Hatch '39
Huron	Harbor Beach	T16N-R15E-S12	
Ingham	Lansing	T4N-R2W	
"	Williamston	T4N-R1E-S36	
Lapeer	Shore Lake Pleasant	T7N-R11E-S4	
Leelanau	Shore Glen Lake	T29N-R14W-S29	
Lenawee	Banks Raisin River	T7S-R4E-S22	
Muskegon	Shore White Lake	T12N-R17W-S33	
Oakland	Shore Lake Orion	T5N-R10E	
Saginaw	Saginaw		Richardson'05
Sanilac	Lexington Twp. L. Huron	T10N-R16E-S13	
Washtenaw	Ann Arbor		Pearse '10
"	Arboretum—Ann Arbor	T2S-R6E-S28	
"	Basement—Ann Arbor	T2S-R6E-S33	
"	Island Park—Ann Arbor	T2S-R6E-S21	

Porcellio scaber, in other parts of the country, has usually been recorded from the vicinity of human settlements (Blake 1931a, Van Name 1936). Not only does it occur within cities and around farms in Michigan, but also in areas devoid of habitations. It has been collected in several cities in Michigan. This isopod also was found in a beech-maple forest some distance from human habitations. There are specimens of *P. scaber* in my collections that were taken from a group of small islands (Pismyre, Hog and Hat) located in Lake Michigan. *Cylisticus convexus* was the only other isopod that occurred on these islands. It is of interest that *P. scaber* was not taken on Mackinac Island, where most of the other terrestrial species were collected.

Porcellio spinicornis Say

According to Van Name (1936) *Porcellio spinicornis* has become established in northeastern North America, where it probably was introduced from Europe. Although a subspecies, *occidentalis,* the identity of which is questioned by Van Name (1940), is found on the Pacific Coast (Miller 1936), *P. spinicornis* has not been reported farther west than Michigan. The northernmost record for the state—Eagle Harbor, Keweenaw County (Hatch 1939)—is nearly at the northern boundary of the species' range as delimited by the Canadian records of Johansen (1926) and Walker (1927).

In the lower peninsula of Michigan it has been found to be widely scattered in its occurrence (Fig. 15, Table 2). It has been collected in eight counties of the lower peninsula, but only from limited areas in each of them. Usually just a few specimens were seen in a single locality. One exception to this occurred during the spring of 1942, when large aggregations were found on a rocky beach of Crystal Lake, Montcalm County. Just previous to the visit to this locality, a great many mayflies had emerged from the lake, and their exuviae had been cast up on the shores in windrows. *P. spinicornis* was found feeding in these piles of exuviae. It was the only isopod present, although not far away *Cylisticus convexus* and *Tracheoniscus rathkei* were collected.

This species of Porcellio apparently is rather restricted in its choice of habitats. Stoller (1902) states that it "seems to prefer the crevices of rocks, specially shady limestone ledges." These also are the situations where this species has been taken most frequently during the present investigation. On Mackinac Island, individual specimens were seen crawling over shaded limestone outcroppings. It has been found on the shores of several lakes (Table 2), where the beaches were composed of either sandy marl or stones.

P. spinicornis has been collected in places usually not considered desirable situations for isopods. It has been taken in the attics of two abandoned farm houses, one in Cheboygan County and the other in Washtenaw County. That these were not accidental records is illustrated by the fact that during three consecutive summers—1940, 1941, 1942—specimens

of this species were collected in the farmhouse in Cheboygan County. Both of these houses were good collecting places for pseudoscorpions which generally prefer a dry situation. In these instances just mentioned, the isopods were found under pieces of fallen plaster, particles of which they may have been ingesting. Many isopods raised in the laboratory in plaster cups have been seen gnawing on the sides of the container. *P. spinicornis* was once taken from a concrete window sill on the third story of the Natural Science Building on the campus of the University of Michigan. It has also been collected along the walls of basements and in a store in Ann Arbor. This peculiar preference for habitats where lime is available may account for the rather spotted occurrence of the species.

TABLE 2. Michigan Records of *Porcellio spinicornis* Say.

COUNTY	LOCALITY	LOCUS KEY	REFERENCE
Bay	Bay City	T14N-R5E	
Cheboygan	Old house, Munro Lake	T37N-R3W-S16	
Keweenaw (UP)	Eagle Harbor		Hatch '39
Lenawee	Shore Devil's Lake	T5S-R1E-S27	
Mackinac (UP)	Mackinac Island	- - - -	
Montcalm	Shore Crystal Lake	T10N-R5W-S9	
Oakland	Shore Deer Lake	T4N-R9E-S30	
Sanilac	Lexington Twp., L. Mich.	T10N-R16E-S13	
Washtenaw	Arboretum—Ann Arbor	T2S-R6E-S28	
"	U. of M. Campus—Ann Arbor	T2S-R6E-S29	
"	Basement—Ann Arbor	T2S-R6E-S33	
"	Island Park—Ann Arbor	T2S-R6E-S21	
"	Deserted House	T2S-R5E-S21	
"	Shore North Lake	T1S-R4E-S18	

Porcellionides pruinosus (Brandt)

From the available data on the distribution of this species in Michigan, it appears to be limited to the southern part of the state (Fig. 16, Table 3). In the northern part of the continent, it has been reported only from southern Ontario, Canada (Walker 1927) and from Massachusetts (Richardson 1905, Blake 1931a). From these northernmost records, it appears that the range of *P. pruinosus* in Michigan may extend somewhat farther north than is apparent from the present records. However, Michigan, north of the localities from which this species was taken, is not as thickly settled as in the southern part. This, then, may partially account for the limited range of *Porcellionides pruinosus* in the state. Hatch (1939) reports it from Detroit, and all of my records are for specimens taken within cities or in highly agricultural areas.

Cylisticus convexus (De Geer)

In the extent of its distribution in Michigan, this species is second only to *Tracheoniscus rathkei*. It is distributed throughout most of the lower peninsula, and has been collected in the Keweenaw Peninsula and Isle Royale of northern Michigan (Fig. 16). In the majority of localities, this species was very numerous. Table 4 lists the records of this species from Michigan, and also indicates that it was taken in many of the townships in Washtenaw and Cheboygan Counties where intensive collections were made. Therefore, further data would probably show this species to be even more abundant than is evident from the present information.

FIG. 16. Distribution within the counties of Michigan of *Armadillidium nasatum* Budde-Lund, *Armadillidium vulgare* (Latreille), *Cylisticus convexus* (De Geer) and *Porcellionides pruinosus* (Brandt). (For key to abbreviations of county names, see explanation of Fig. 15.)

TABLE 3. Michigan Records of *Porcellionides pruinosus* (Brandt).

COUNTY	LOCALITY	LOCUS KEY	REFERENCE
Eaton	Shore Pine Lake	T1N-R5W-S31	
Ingham	Williamston	T4N-R1E-S36	
Monroe	Banks Raisin River	T6S-R7E-S14	
"	Toledo Beach, L. Erie	T7S-R9E-S31	
Washtenaw	Arboretum—Ann Arbor	T2S-R6E-S28	
Wayne	Detroit		Hatch '39

Cylisticus convexus has been collected in many different types of habitats. It was particularly abundant on most of the rocky beaches where collections were made. It has also been taken on other types of beaches as well as along river banks, when drift and other debris were present, but seldom was it as plentiful as on the rocky shores. When found along lakes, this species was more abundant in the region of the middle beach than on either the inner or outer beaches, where usually only scattered individuals were to be found. In Michigan, *C. convexus* was very abundant on several small islands in Lake Michigan belonging to Charlevoix County. These islands are principally gull and tern rookeries some distance from the mainland. Only this species and *Porcellio scaber* were collected there during the summers of 1940 and 1941. *C. convexus* has been

taken from limestone outcroppings and quarries in the northern part of the lower peninsula. Occasionally in Michigan it has been found along the margins of mixed deciduous woods. It was not abundant in the last situation. Never was it collected in central portions of woodlands, unless roads or other man-made clearings were present. This species, like many of the other terrestrial isopods, is to be found in large numbers within cities. It is the predominant species on Mackinac Island, which was among the first places in Michigan to be settled. In general, *Cylisticus convexus* prefers a more moist situation than do the species of Armadillidium, Porcellio and Tracheoniscus. This is illustrated by the fact that it is very abundant in such moist situations as rocky beaches and along river banks, where it may be the predominant isopod, while on the other hand, in drier conditions, such as are found in cities and woodlands, it is scattered and is not an abundant species.

TABLE 4. Michigan Records of *Cylisticus convexus* (De Geer).

COUNTY	LOCALITY	LOCUS KEY	REFERENCE
Antrim	Woodland, Elk Rapid Twp.	T29N-R9W-S29	
Barry	Shore Gun Lake	T2N-R10W-S5	
Branch	Shore Coldwater Lake	T7S-R6W-S35	
Calhoun	Park—Lee Twp.	T1S-R5W-S7	
Charlevoix	Shore L. Charlevoix	T33N-R7W-S15	
"	Hat Isl., L. Michigan	- - - -	
"	Hog Isl., L. Michigan	- - - -	
"	Pismyre Isl., L. Mich.	- - - -	
Cheboygan	Shore Douglas Lake	T37N-R3W-S33	
"	Shore Burt Lake	T36N-R3W-S8	
"	Banks of Mill Creek	T39N-R3W-PC334	
"	Campbell Quarry	T35N-R2W-S36	
"	Banks Sturgeon River	T33N-R2W-S7	
"	Aloha State Park	T36N-R1W-S8	
"	Shore Long Lake	T36N-R1W-S12	
Eaton	Shore Pine Lake	T1N-R5W-S31	
Emmet	Shore Lake Michigan	T38N-R6W-S34	
"	Shore Straits Mackinac	T39N-R4W-S11	
Genesee	Flint		
Gladwin	Gladwin State Park	T18N-R2W-S1	
Houghton (UP)	Calumet		Hatch '39
Huron	Harbor Beach	T16N-R15E-S12	
"	Owendale	T15N-R10E-S15	
Ingham	Lansing	T4N-R2W	
Kalamazoo	Woods W. of Schoolcraft	T4S-R12W-S13	
Keweenaw (UP)	Eagle Harbor		Hatch '39
"	Isle Royale		Adams '09
Leelanau	Shore Glen Lake	T29N-R14W-S29	
Lenawee	Shore Devil's Lake	T5S-R1E-S27	
"	Banks Wolf Creek	T6S-R3E-S31	
"	Banks Raisin River	T7S-R4E-S22	
Mackinac (UP)	Mackinac Island	- - - -	
"	Bois Blanc Island	- - - -	
Macomb	Banks Clinton River	T2N-R14E	
Manistee	Orchard Beach St. Park	T22N-R17W-S25	
Monroe	Banks Raisin River	T6S-R7E-S14	
"	Toledo Beach, L. Erie	T7S-R9E-S31	
Montcalm	Shore Crystal Lake	T10N-R5W-S9	
Montmorency	Banks Thunder Bay River	T31N-R4E-S23	
Muskegon	Shore White Lake	T12N-R17W-S33	
Oakland	Shore Lake Orion	T5N-R10E	
Presque Isle	Shore Grand Lake	T33N-R8E-S8	
"	Shore Black Lake	T35N-R2E-S8	
Saginaw	Saginaw		Richardson'05
Sanilac	Lexington Twp. L. Huron	T10N-R16E-S13	
"	Delaware Twp. L. Huron	T14N-R16E-S32	
Washtenaw	Ann Arbor		Pearse '10
"	Ann Arbor		Hatch '39
"	Arboretum—Ann Arbor	T2S-R6E-S28	
"	Island Park—Ann Arbor	T2S-R6E-S21	
"	Basement—Ann Arbor	T2S-R6E-S33	
"	White's Woods	T2S-R6E-S30	
"	Shore Sugar Lake	T2S-R3E-S32	
"	Field on Chelsea Road	T1S-R3E-S22	
Wayne	Detroit		Hatch '39

Tracheoniscus rathkei (Brandt)

Tracheoniscus rathkei, which is widely distributed in eastern United States (Van Name 1936), is to be found throughout all of the lower peninsula of Michigan (Fig. 17). It has also been collected in the eastern part of the upper peninsula—Chippewa, Luce and Mackinac Counties. There are no records from the remaining counties in that part of the state. For the lower peninsula, however, there are records of this species for every county (Table 5). *T. rathkei* is the predominant terrestrial isopod of the region. It occurs in great abundance in most parts of southern Michigan. There is only one region of the lower peninsula in which this species is not abundant—the jack pine belt that stretches across the north-central area of the peninsula. In this region it is usually the only terrestrial isopod to be found (Figs. 17 & 19). However, *Cylisticus convexus* and *Porcellio scaber* may occasionally occur along water courses or in towns of this zone. In contrast to *Porcellio spinicornis, T. rathkei* does not appear to be specific in its habitat preferences. This adaptability to various conditions may account for its wide distribution and abundance in the state.

Habitats for this species cited by Richardson (1905) are "woodsheds, greenhouses, on rotton logs, under bricks and boards, under logs, at river bot-

FIG. 17. Distribution within the counties of Michigan of *Tracheoniscus rathkei* (Brandt). (For key to abbreviations of county names, see explanation to Fig. 15.)

TABLE 5. Michigan Records of *Tracheoniscus rathkei* (Brandt).

COUNTY	LOCALITY	LOCUS KEY	REFERENCE
Alcona	Harrisville		UMMZ
"	Woodland S. of Glennie	T25N-R6E	
"	Pasture E. of Curran	T28N-R5E	
Allegan	Woodland N. of Wayland	T4N-R11W-S31	
"	Field W. of Dorr	T4N-R12W-S16	
"	Field E. of Overisel	T4N-R14W-S13	
Alpena	Woodland, Alpena Twp.	T32N-R8E-S27	
Antrim	Woodland, Elk Rapids Twp.	T29N-R9W-S29	
"	Pasture N. of Mud Lake	T30N-R9W-S24	
Arenac	Maple woods, Standish Twp.	T18N-R4E-S35	
"	Woodland, Au Gres Twp.	T19N-R6E-S16	
"	Shore Lake Huron	T20N-R7E-S12	
Barry	Shore Gun Lake	T2N-R10W-S5	
"	Woodland, Woodland Twp.	T4N-R7W-S12	
Bay	Bay City	T14N-R5E	
"	Woodland N. of Kawkawlin	T15N-R4E-S35	
Benzie	Woodland E. of Honor	T26N-R14W-S9	
"	Shore Platte Lake	T27N-R15W-S36	
Berrien	Pasture near St. Joseph R.	T5S-R18W-S4	
"	Shore Lake Michigan	T3S-R18W-S11	
Branch	Shore Coldwater Lake	T7S-R6W-S35	
"	Banks Prairie River	T7S-R8W-S25	
Calhoun	Park—Lee Twp.	T1S-R5W-S31	
"	Pasture, Battle Creek Twp.	T2S-R8W-S17	
Cass	Woodland, Marcellus Twp.	T5S-R13W-S13	
"	Banks Dowagiac Creek	T5S-R16W-S35	
Charlevoix	Pasture, Norwood Twp.	T33N-R8W-S24	
"	Shore Lake Charlevoix	T33N-R7W-S15	
Cheboygan	Burt Lake		Hatch '39
"	Shore Burt Lake	T36N-R3W-S8	
"	Shore Burt Lake	T36N-R3W-S17	
"	Shore Douglas Lake	T37N-R3W-S28	
"	Shore Douglas Lake	T37N-R3W-S17	
"	Shore Munro Lake	T37N-R3W-S9	
"	Indian River St. Park	T35N-R3W-S25	
"	Banks Mill Creek	T29N-R3W-PC334	
"	Shore Silver Lake	T33N-R3W-S11	
"	Campbell Quarry	T35N-R2W-S36	
"	Woodland, Pigeon River	T34N-R2W-S2	
"	Woodland E. of Wolverine	T33N-R2W-S8	
"	Aloha State Park	T36N-R1W-S8	
"	Shore Long Lake	T36N-R1W-S12	
"	Banks Milliken Creek	T34N-R1W-S3	
"	Banks Milliken Creek	T34N-R1W-S14	
"	Pigeon River St. Forest	T34N-R1W-S32	
"	Banks Black River	T34N-R1E-S11	
"	Banks Nigger Creek	T36N-R2W-S16	
"	Dried Bog, Hebron Twp.	T38N-R3W-S31	
Chippewa (UP)	Shore Lake Superior	T48N-R7W-S15	
Clare	Pasture, Arthur Twp.	T18N-R3W-S2	
"	Pasture, Hatton Twp.	T18N-R4W-S25	
"	Shore Shingle Lake	T18N-R5W-S8	
Clinton	Maple Woods, Ovid Twp.	T7N-R1W-S6	
"	Hardwoods, Riley Twp.	T6N-R3W-S8	
"	Pasture, Watertown Twp.	T5N-R3W-S1	
Crawford	Banks Au Sable River	T26N-R1W-S29	
"	Shore Lake Margrethe	T26N-R4W-S10	
Eaton	Woods S. of Grand Ledge	T3N-R4W-S2	
"	Banks Battle Creek	T2N-R4W-S19	
"	Shore Pine Lake	T1N-R5W-S31	
Emmet	Shore Lake Michigan	T39N-R6W-S34	
"	Shore Straits of Mackinac	T39N-R4W-S11	
"	Shore Straits of Mackinac	T39N-R4W-S28	
"	Shore Carp Lake	T38N-R4W-S15	
"	Shore Carp Lake	T38N-R4W-S24	
Genesee	Flushing State Park	T8N-R5E-S27	
Gladwin	Shore Wixon Lake	T17N-R1W-S36	
"	Gladwin State Park	T18N-R2W-S1	

TABLE 5. Michigan Records of *Tracheoniscus rathkei* (Brandt)—(Continued).

COUNTY	LOCALITY	LOCUS KEY	REFERENCE
Grand Traverse	Woodland, Paradise Twp.	T25N-R10W-S1	
"	Woodland, Blair Twp.	T26N-R11W-S20	
Gratiot	Woodland E. of Newark	T10N-R3W-S14	
Hillsdale	Hardwoods, Hillsdale Rd.	T7S-R3W-S23	
"	Pasture, Edon Road	T8S-R4W-S2	
Huron	Farm, McKinley Twp.	T17N-R10E-S28	
"	Owendale	T15N-R10E-S15	
"	Swamp, Sand Beach Twp.	T16N-R15E-S1	
"	Shore Lake Huron	T18N-R14E-S2	
Ingham	Field, Leroy Twp.	T3N-R2E-S4	
"	Field, Howell Road	T3N-R1W-S34	
"	Pasture, Onondago Road	T2N-R2W-S9	
"	Banks Grand River	T1N-R2W-S28	
"	Near House, Lansing	T4N-R2W	
"	Near House, Williamston	T4N-R1E-S36	
Ionia	Woodland S. of Belding	T8N-R8W-S23	
"	Hardwoods N. of Saranac	T6N-R8W-S1	
"	Shore Morrison Lake	T6N-R8W-S36	
Iosco	Creek Bed, Alabaster Twp.	T21N-R7E-S14	
Isabella	Pasture, Broomfield Twp.	T14N-R6W-S23	
"	Banks Chippewa River	T14N-R5W-S17	
Jackson	Banks Grand River	T1S-R1W-S35	
"	Vineyard Lake St. Park	T4S-R2E-S28	
Kalamazoo	Woodland near Indian L.	T4S-R10W-S9	
"	Farmland, Comstock Twp.	T2S-R10W-S6	
"	Woodland, Prairie Twp.	T4S-R12W-S13	
Kalkaska	Field, Kalkaska	T27N-R7W-S17	
Kent	Pasture, Walker Twp.	T7N-R12W-S2	
"	Woodland, Alpine Twp.	T8N-R12W-S12	
Lake	Manistee National Forest	T17N-R11W-S6	
Lapeer	Woodland on US53	T7N-R12E-S29	
"	Shore Lake Pleasant	T7N-R11E-S4	
"	Shore Lake Nepessing	T7N-R9E-S23	
Leelanau	Shore Glen Lake	T29N-R14W-S29	
"	Pasture, Solon Twp.	T28N-R12W-S8	
Lenawee	Shore Evans Lake	T5S-R3E-S6	
"	Banks Raisin River	T7S-R4E-S22	
"	Field along Wolf Creek	T6S-R3E-S31	
"	Shore Devil's Lake	T5S-R1E-S27	
"	Shore Iron Lake	T5S-R2E-S2	
Livingston	Woodland near Hartland		UMMZ
"	Shore Strawberry Lake	T1N-R5E-S27	
"	Shore Brighton Lake	T2N-R5E-S36	
"	Field along Cedar River	T4N-R3E-S32	
"	Banks Huron River	T1N-R5E-S24	
Luce (UP)	Soo Juction	T46N-R8W-S35	
Mackinac (UP)	Mackinac Island	- - - -	
"	Bois Blanc Island	- - - -	
"	Swamp along Paquin Creek	T43N-R7W-S34	
Macomb	Shore Lake St. Clair	T1N-R13E	
"	Banks Clinton River	T2N-R13E	
Manistee	Shore Bar Lake	T24N-R16W-S15	
"	Orchard Beach St. Park	T22N-R17W-S25	
"	Shore Portage Lake	T23N-R16W-S36	
"	Banks Cedar Creek	T23N-R13W-S5	
Mason	Shore Emerson Lake	T18N-R15W-S15	
"	Woodland Custer Twp.	T18N-R16W-S14	
Mecosta	Woodland near Big Rapids		UMMZ
"	Banks Muskegon River	T14N-R10W-S20	
"	Shore Section Lake	T14N-R8W-S16, 21	
Midland	Banks Chippewa River	T14N-R2W-S8	
"	Woodland, Homer Twp.	T14N-R1E-S16	
Missaukee	Lake Missaukee St. Park	T22N-R8W-S1	
"	Pasture, Reeder Twp.	T22N-R7W-S1	
"	Banks Muskegon River	T23N-R5W-S35	
Monroe	Banks Raisin River	T6S-R7E-S11	
"	Toledo Beach, L. Erie	T7S-R9E-S31	
"	Woodland, Bullock School	T8S-R7E-S9	
Montcalm	Woodland E. of Crystal	T10N-R5W-S15	
"	Shore Crystal Lake	T10N-R5W-S9	

TABLE 5. Michigan Records of *Tracheoniscus rathkei* (Brandt)—(Continued).

COUNTY	LOCALITY	LOCUS KEY	REFERENCE
Montealm	Pasture	T10N-R6W-S21	
Montmorency	Pasture	T32N-R4E-S24	
"	Banks Thunder Bay River	T31N-R4E-S23	
"	Woodland along Smith Creek	T30N-R3E-S7	
"	Banks Hay Meadow Creek	T30N-R2E-S11	
Muskegon	Woodland W. of Casnovia	T10N-R13W-S19	
"	Shore White Lake	T12N-R17W-S33	
Newaygo	Woodland E. of Hesperia	T14N-R14W-S32	
"	Banks White River	T14N-R13W-S30	
Oakland	Sylvan Lake		Hatch '39
"	Fenton		UMMZ
"	Woodland near Co. Line		UMMZ
"	Woodland E. of South Lyon		UMMZ
"	Shore Deer Lake	T4N-R9E-S30	
"	Park, Southfield Twp.	T1N-R10E-S8	
Oceana	Pasture, Newfield Twp.	T14N-R15W-S32	
Ogemaw	Banks Rifle River	T22N-R3E-S21	
"	Banks Nester Creek	T22N-R4E-S22	
Osceola	Woodland, Osceola Twp.	T18N-R8W-S36	
"	Banks McKinstry Creek	T17N-R9W-S19	
Oscoda	Pasture, Big Creek Twp.	T26N-R2E-S19	
Otsego	Shore Cogswell Lake	T31N-R3W-S35,36	
Ottawa	Woodland N. of Holland	T6N-R15W-S32	
"	Woodland, Springlake	T8N-R16W-S24	
"	Woodland, Wright Twp.	T8N-R13W-S34	
Presque Isle	Shore Grand Lake	T33N-R8E-S8	
"	Shore Lake Huron	T37N-R2E-S14	
"	Shore Little Lake	T35N-R6E-S30	
"	Shore Ocqueoc Lake	T36N-R3E-S30	
"	Farmland E. of Onaway	T34N-R3E-S6	
"	Field S. E. of Millersberg	T34N-R3E-S25	
"	Pasture S. of Hawks	T33N-R4E-S12	
Roscommon	Shore Houghton Lake	T22N-R4W-S3	
"	Field, Roscommon Twp.	T23N-R4W-S33	
"	Woodland, Richfield Twp.	T23N-R1W-S7	
Saginaw	Sagniaw		Richardson'05
"	Creek banks, Albee Twp.	T10N-R4E-S34	
"	Banks Shiawassee River	T10N-R3E-S22	
"	Dump E. of Brant	T10N-R2E-S17	
Sanilac	Shore Lake Huron	T14N-R16E-S32,18	
Shiawassee	Woodland, Bancroft Road	T5N-R3E-S11	
"	Banks Shiawassee River	T6N-R3E-S14	
St. Clair	Banks Belle River	T5N-R15E-S32	
St. Joseph	Shore Klinger Lake	T8S-R11W-S2	
"	Banks St. Joseph River	T5S-R9W-S32	
"	Woodland, Flowerfield Twp.	T5S-R12W-S27	
Tuscola	Woodland along US 23	T14N-R8E-S3	
Van Buren	Pasture, Geneva Twp.	T1S-R16W-S12	
"	Woodland N. of Gobles	T1S-R13W-S18	
Washtenaw	Ann Arbor		Pearse '10
"	Ann Arbor		Hatch '39
"	Woodland on Geddes Road		UMMZ
"	Woodland, Joy & Pontiac Rds.		UMMZ
"	Superior Twp.		UMMZ
"	Arboretum—Ann Arbor	T2S-R6E-S28	
"	Saginaw Forest	T2S-R5E-S25	
"	White's Woods	T2S-R6E-S30	
"	Dexter—Huron Park	T2S-R5E-S5	
"	Shore Cavanaugh Lake	T2S-R3E-S8	
"	Shore Sugar Loaf Lake	T2S-R3E-S32	
"	Loch Alpine Park	T2S-R5E-S3	
"	Swamp along Zeeb Road	T2S-R5E-S27	
"	Pasture along Sylvan Road	T3S-R5E-S3	
"	Pasture along Dancer Road	T3S-R4E-S26	
	Shore North Lake	T1S-R4E-S18	
Washtenaw	Field along Chelsea Road	T1S-R3E-S22	
Wayne	Redford Golf Course		UMMZ
"	Huron River Park	T4S-R9E-S27	
Wexford	Banks Manistee River	T23N-R12W-S11	
"	Banks Soper Creek	T23N-R10W-S5	

tom." For Michigan, at least, several more situations should be added. It is abundant in cities, but is not, as Van Name (1936) implies, to be found primarily around human settlements. More than any other species, *Tracheoniscus rathkei* is to be found in the woods. Very few deciduous woods that were investigated in the lower peninsula failed to yield at least one specimen of this species. On the few occasions when it was not collected, the woods were usually so dense that the forest floor was almost devoid of animal life, or the situation was much too dry. This species is the only isopod that has been collected in the aspen woods of Michigan, and in these few instances it was not particularly numerous. Dryness of the forest floor may be one reason why isopods are usually not to be found in aspen associations. *T. rathkei* occurred in temporary pools that had dried up in early summer, although it might be the only terrestrial animal, with the possible exception of land snails, which had invaded the area. Of primary importance among the specific woodland habitats frequented by this species are rotting logs and stumps. From late fall through winter to spring, decaying logs seem to be preferred to other situations, since large aggregations have been found there when the species could not be collected elsewhere in the region. *Tracheoniscus rathkei*, although typically a woodland species, nevertheless also frequents lake shores, pastures, grasslands, and cleared areas along roadsides.

Armadillidium vulgare (Latreille)

This isopod has been collected in widely scattered areas in the lower peninsula of Michigan (Fig. 16; Table 6). The northernmost records reported by others are Salem, Massachusetts (Blake 1931a), Toronto, Canada (Walker 1927) and Seattle, Washington (Hatch 1939). In Canada, it is principally found in greenhouses (Walker 1927). During the summer of 1942 several specimens were collected along the beach of Fairy Island, Douglas Lake, Cheboygan County. This locality is farther north than the first two records cited above, and has a more rigorous climate than Seattle. The area where the collection was made had been intensively searched during the three preceding summers and during these periods *A. vulgare* had not been collected there. It is my opinion, therefore, that the lack of previous records from this locality can be explained only by assuming that this species had been introduced into the region during the spring or early summer of 1942, when plantings of decorative shrubs, not in-

TABLE 6. Michigan Records of *Armadillidium vulgare* (Latreille).

COUNTY	LOCALITY	LOCUS KEY	REFERENCE
Bay	Near dwelling, Bay City	T14N-R5E	
Branch	Beach, Coldwater Lake	T7S-R6W-S35	
Cass	Banks, Dowagiac Creek	T5S-R16W-S35	
Cheboygan	Fairy Island, Douglas L.	T37N-R3W-S30	
Ingham	Near dwelling, Lansing	T4N-R2W	
Monroe	Toledo Beach on L. Erie	T7S-R9E-S31	
Washtenaw	Ann Arbor		Hatch '39
"	Arboretum—Ann Arbor	T2S-R6E-S28	
"	Basement—Ann Arbor	T2S-R6E-S33	
"	Bot. Garden—Ann Arbor	T2S-R6E-S31	
"	U. of M. campus—Ann Arbor	T2S-R6E-S29	
"	Greenhouse—Ann Arbor	T2S-R6E-S21	
"	Beach of North Lake	T1S-R4E-S18	
Wayne	Detroit		Hatch '39

digenous to the region, were made on that part of the island.

Armadillidium nasatum Budde-Lund

This species, which is here reported from the state for the first time, has been collected in only one locality—greenhouses of the University of Michigan Botanical Gardens, Ann Arbor, Washtenaw County. This isopod has been reported as far north as London, Ontario (Ross 1914) and as far west at Mt. Pleasant, Iowa (Longnecker 1924). In greenhouses in Michigan it was found with *Armadillidium vulgare*, which was as abundant outdoors as in these buildings. *A. nasatum*, however, was never found outside of the greenhouses, although inside it was as common as *A. vulgare*.

AQUATIC SPECIES

Asellus communis Say

Records which are available at the present time appear to indicate that this is the most abundant freshwater isopod in Michigan. It appears to be distributed throughout most of the state (Fig. 18). Van Name (1936) reports it to be "by far the most abundant and widely distributed fresh-water isopod in the eastern half of the United States." In Michigan, it has been collected in many different aquatic environments (Table 7). It has been found in trout streams, creeks, roadside ditches, drainage ditches, and rivers, in springs, swamps, millponds, permanent woodland ponds, temporary ponds and lakes. In Michigan, it usually was found on the bottom among detritus, or clinging to aquatic vegetation, or in mats of filamentous algae. However, *A. communis* also occurred under rocks in rapid streams. Only once was this species found swimming, but in this case—a woodland pool—it was very abundant and constituted the principal animal life of the pool.

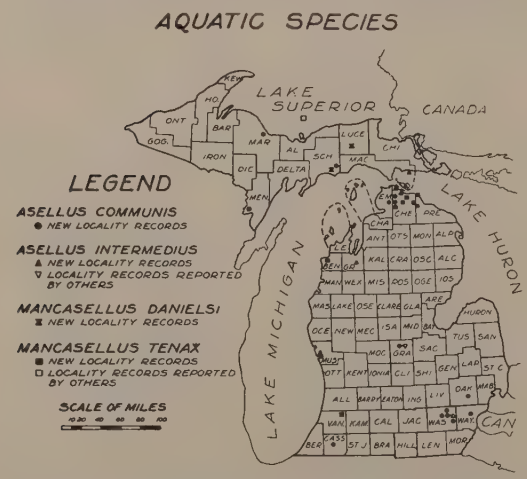


FIG. 18. Distribution within the counties of Michigan of *Asellus communis* Say, *Asellus intermedius* Forbes, *Mancasellus danielsi* (Richardson) and *Mancasellus tenax* (Smith). (For key to abbreviations of county names see explanation of Fig. 15.)

TABLE 7. Michigan Records of *Asellus communis* Say.

COUNTY	LOCALITY	LOCUS KEY	REFERENCE
	Michigan		Richardson'05
Cass	Crystal Springs		UMMZ
Cheboygan	Carp Creek at Burt Lake	T36N-R3W-S4	Dendy '44
"	Douglas Lake	T37N-R3W-S33	
Emmet	Maple River at Power Dam	T36N-R4W-S10	
Gratiot	Alma		UMMZ
Kent	Grand Rapids		Smith 1874
Manistee	Bar Lake	T24N-R16W-S15	
Marquette (UP)	Mill Pond, Marquette		UMMZ
"	Frisnore Pond, Marquette		UMMZ
Oakland	Woodland Pond, Bloomfield		UMMZ
Schoolcraft (UP)	Pelkner Lake, Blaney Park		UMMZ
Washtenaw	Woodland Pond, Ann Arbor		UMMZ
"	Stream, White's Woods		UMMZ
"	Geddes Pond, Huron River	T2S-R6E-S26	
"	Pool, U. of M. Campus	T2S-R6E-S29	
"	Delhi Rapids, Huron River	T2S-R5E-S2	
"	Roadside Pool, Ypsilanti	T3S-R7E-S5	
"	Swamp, Liberty & Zeeb Rds.	T2S-R5E-S27	
Wayne	Creek, Redford Golf Course		UMMZ

Asellus intermedius Forbes

Although its distribution in North America is not as well known as that of *Asellus communis*, since reported records are rather few, *A. intermedius* is known to occur from the vicinity of Brunswick and Portland, Maine (Norton 1909) as far west as Omaha, Nebraska (Pearse 1913). In Michigan, it has been collected from Washtenaw County in the south to Cheboygan County and Bois Blanc Island in the north (Fig. 18). In my collections, there are specimens from lakes, springs and swamps (Table 8). It has been collected in situations similar to those habitats described for *A. communis*. Usually there is but one species of aquatic isopod for any

TABLE 8. Michigan Records of *Asellus intermedius* Forbes.

COUNTY	LOCALITY	LOCUS KEY	REFERENCE
Cheboygan	Springs, Straits Mackinac	T39N-R3W-PC334	
"	Roadside Park Spring	T38N-R2W-S6	
Grand Traverse	Boardman Lake		UMMZ
Gratiot	Alma		Pearse '13
Mackinac (UP)	Duncan Lake, Bois Blanc Is.	- - - -	
Muskegon	Muskegon Lake		UMMZ
Washtenaw	Steere's Swamp—Ann Arbor		Pearse '12
"	Swamp, Liberty & Zeeb Rds.	T2S-R5E-S27	

TABLE 9. Michigan Records of *Mancasellus tenax* (Smith).

COUNTY	LOCALITY	LOCUS KEY	REFERENCE
	Michigan		Richardson'05
	Lake Huron		Richardson'05
Alpena	Thunder Bay, Lake Huron		Smith 1874
Benzie	Big Platte Lake		UMMZ
Cheboygan	Black Lake		UMMZ
"	Creek S. of Cheboygan	T37N-R1W-S8	
"	Maple River at Burt Lake	T36N-R3W-S32	
"	Mouth of Nigger Creek	T36N-R2W-S16,17	
Chippewa (UP)	Whitefish Point		Hankinson'16
Menominee (UP)	Baker Lake		UMMZ
"	Bass Lake		UMMZ
"	Becker Lake		UMMZ
"	Lake Ann		UMMZ
Presque Isle	Black Lake		UMMZ
"	Clear Lake	T37N-R2E-S1	
Van Buren	North Lake		UMMZ

particular habitat. However, in a swamp in Washtenaw County both *A. communis* and *A. intermedius* were collected in approximately equal numbers. Johansen (1920) and Van Name (1936) have pointed out the possibility that there two species may not be distinct.

Mancasellus danielsi Richardson

This isopod has been reported previously only from Indiana and Illinois. The Michigan records, based on specimens in the University of Michigan Museum of Zoology, are from the upper peninsula—Tahquamenon River, Luce County and Gulliver Lake, Schoolcraft County (Fig. 18).

Mancasellus dilatus (Smith)

There is only one record—the original—of this species for Michigan. It was collected on the Detroit River at Ecorse in Wayne County (Smith 1874).

Mancasellus tenax (Smith)

According to available data, *M. tenax,* which is second only to *Asellus communis* in abundance in Michigan, appears to be limited to the Great Lakes region. The localities in this state from which it has been collected are scattered over the lower peninsula (Fig. 18). Creeks, rivers, large and small lakes were found to be inhabited by this species (Table 9). It frequents the bottoms of shallow waters, occurring under logs and debris. Like other freshwater isopods, this species has been seen crawling on stems and under surfaces of leaves of submerged aquatic vegetation.

A few of the previous Michigan records for *Mancasellus tenax* are somewhat confusing. Among the localities for this species cited by Richardson (1905) are "Lake Superior; . . . Michigan; Lake Huron." However, she does not state where in these extensive areas the specimens were collected. Pearse (1910), in his "Preliminary List of the Crustacea of Michigan," quotes these three records of Richardson in his table of Michigan localities for this species. Although Richardson does not say where she obtained her data, the lake records were probably based on those of Smith (1874) which is the only paper prior to 1905 that lists these localities. The Lake Huron specimens were taken from Thunder Bay (Smith 1874), and therefore their record is a legitimate one for Michigan. However, Smith made his Lake Superior collections off the shores of the island of Saint Ignace and in waters around the Slate Islands, all of which are located in the Canadian part of the lake. It would appear, therefore, that the Lake Superior record of Pearse is a doubtful one for Michigan. For these reasons, this particular record has not been included in the present Michigan records of this species.

HABITAT SELECTION

Although our knowledge of the distribution in Michigan of terrestrial isopods is not complete, there are sufficient data available to warrant a discussion of the preferences of certain species for specific habitats and of their general distribution throughout the lower peninsula. Some isopods have been found in many different types of situations throughout the area. Others are more particular and appear to be limited to several distinct environments or occur only in certain regions of the state, while a few ordinarily are found only in one particular type of habitat.

The lower peninsula of Michigan may be divided into three regions in respect to the terrestrial isopod fauna of the state. The southern section extends as far north as Bay City on the east, and Muskegon on the west. The northern district borders Lake Michigan, the Straits of Mackinac and Lake Huron, but it does not extend inland for any great distance except along the water courses. It consists of parts of Leelanau, Grand Traverse, Antrim, Charlevoix, Emmet, Cheboygan and Presque Isle Counties. The third area comprises the remaining central counties. There are few records of terrestrial isopods from this middle district. The reason for this is to be found in the nature of the region. Much of this part of the state is sparsely settled and has been burned over several times. The area is now characterized by jack pine uplands. The great majority of invertebrate animals usually associated with ter-

restrial isopods are absent from the region. *Tracheoniscus rathkei* was the only species found in most of the district, and it was not as abundant there as elsewhere. In this area occasional individuals of *Porcellio scaber* and of *Cylisticus convexus* were obtained along river banks and in towns, but these specimens were rare. Isopod populations in the northern and southern regions were larger than those in the central section.

Some of the terrestrial isopods appear to be restricted to the southern part of the state; others are more abundant in the south, but are occasionally to be found in the north; and still others are widespread in their distribution throughout most of the state (Fig. 19). *Porcellionides pruinosus* has been collected only in the southeastern section of Michigan, and *Ligidium longicaudatum* is known from only three southern counties. On the other hand, *Armadillidium vulgare* occurs as far north as Bay City and once was found as far north as Douglas Lake. This particular instance has been discussed previously. Between Bay City and Douglas Lake it is not known. Among the species that are distributed throughout the state are the three common isopods *Cylisticus convexus, Porcellio scaber* and *Tracheoniscus rathkei.* The factors that limit the distribution of terrestrial isopods may be climate or the influence of man.

FIG. 19. Distribution in Michigan according to counties of the fifteen species of isopods known to occur in the state. (For key to abbreviations of county names see explanation of Fig. 15.)

The majority of terrestrial isopods are said to be natives of Europe that have been introduced on this continent. This probably accounts for their abundance around human settlements—farms, public beaches, parks, cities and towns. In these places most of the terrestrial forms are to be found. In Michigan, the typical habitat for the three species *Armadillidium vulgare, Oniscus asellus* and *Porcellionides pruinosus* is around dwellings. Occasionally *Cylisticus convexus, Porcellio scaber* and *Tracheoniscus rathkei* also occur here, but generally are not as numerous. All seven of these species have been collected in dwellings as well as out-of-doors.

Along various types of lake shores as well as along different types of river and stream banks one finds different species of isopods. *Cylisticus convexus* has been found on protected rocky beaches and river banks. It usually inhabits the middle beach. In Michigan, according to available records, this particular situation is preferred by this species. Here it occurs frequently and usually in large numbers. *Tracheoniscus rathkei* and *Porcellio scaber* are also found on rocky shores of lakes and rivers, but are scattered and are never as numerous as *Cylisticus convexus.* On the other hand, on sandy, debris-littered shores, *Porcellio scaber* is the predominant species. It, however, prefers the outer beach in such situations. If the lake or stream is in a well populated district *Armadillidium vulgare* may be found along it, but on sparsely settled shores it was not collected.

In areas that are usually wet, but not subject to flooding, such as certain marshlands, *Ligidium longicaudatum* will be found. In Michigan, although seldom collected, all specimens of this species were taken from such regions. *Trichoniscus demivirgo* also prefers a wetter situation than do most of the other terrestrial isopods. It has been found around Ann Arbor in deciduous woodlands under leaves and stones, in ditches or well protected places that are usually wet.

Stoller (1902) is of the opinion that the common name "Woodlouse," if applied to any isopod, should be used for *Tracheoniscus rathkei.* In Michigan, it, more than any other species, is a woodland form. As previously stated, it is to be found in the great majority of deciduous woods of the lower peninsula, where it is the predominant isopod. However, an occasional *Porcellio scaber* or *Cylisticus convexus* may be found along the margins of deciduous woods. If the wooded area is wet *Trichoniscus demivirgo* may occur.

There are at least two types of Michigan woodlands that typically do not harbor isopods. These are the aspen woods and the coniferous forests. The animals usually associated with terrestrial isopods are also absent from many of these areas. Aspen woodlands are generally dry, and this may explain in part the absence of isopods.

LIFE HISTORY STUDIES OF FOUR TERRESTRIAL SPECIES

HISTORICAL

Calman in 1911 wrote, "Although woodlice are very common animals, comparatively little is known of their habits." This statement is still applicable today, and especially is it true for our American forms. As previously stated, it is thought that many of our terrestrial isopods originated in the Old World, and therefore, the results obtained from biological investigations carried out in Europe for

these particular species may possibly be pertinent for our fauna. However, it has been only within recent years that the many specialists working on this group in Europe have emphasized their biology. One of the pioneer European papers on life history studies of these isopods was that by W. E. Collinge (1915). The paucity of previous publications of this nature is strikingly shown in Collinge's bibliography of five rather short articles. K. W. Verhoeff, an outstanding systematist of the group, has contributed much to the present status of our knowledge of them. A. Vandel, working on the genetics of terrestrial isopods, reported various phases of natural history that he encountered in his studies in France. H. W. Howard (1940), also primarily interested in isopod genetics, described, in general, the life history of *Armadillidium vulgare*. Several European publications on distribution, genetics and taxonomy of the group contain scattered bits of information on natural history, but these data are meager and far from complete.

Inasmuch as there have been only a few students of Isopoda in America, we are far behind Europe in our knowledge concerning them. The American specialists, for the most part, have been primarily interested in taxonomy or experimental biology and have almost completely neglected other biological aspects, especially the life histories of these crustaceans. Among the first American papers to deal with their general biology was Richardson's "Contributions to the Natural History of the Isopoda" (1904). This paper largely emphasized marine forms and gave only generalities for the terrestrial group. Probably one of the more important American articles was Pierce's "Notes on the Economic Importance of Sowbugs" (1907). Life history data of three isopods (*Armadillidium vulgare, Porcellio laevis,* and *Porcellionides pruinosus*) are given in his discussion on their depredations to crops around Dallas, Texas. Although much has been written concerning the reactions of certain species to light, moisture, contact and similar phenomena (Abbott 1918, Allee 1923, 1926, Brooks 1942, Miller 1938, and others) very little is known concerning the rest of their biology. The present investigation, therefore, extends our knowledge of the life histories of four common terrestrial species.

Materials and Methods

The terrestrial isopods selected for study in the laboratory were chosen because they were abundant around Ann Arbor and were able to thrive under laboratory conditions. They were *Armadillidium vulgare* (Latreille), *Cylisticus convexus* (De Geer), *Porcellio scaber* Latreille, and *Tracheoniscus rathkei* (Brandt). For the most part, the present studies were based on animals raised in the laboratory, but field observations were made to substantiate laboratory results.

Several workers have described methods for raising sowbugs, but all had certain limitations as far as the present problem was concerned. Collinge (1915) used glass observational cells similar to those employed in raising ants. Abbott (1918) reared his specimens in covered glass dishes containing earth, dry leaves and bark. Fuller (1937) recommended glass-covered, wooden boxes big enough to accommodate a thousand animals. Howard (1940) used "one pound jars with metal screw caps" as well as Petri dishes 10 cm. in diameter containing wet filter paper. During the present investigation, Abbott's method with certain modifications was used for rearing general cultures. Pulverized soil to a depth of one inch was placed in large, round, glass dishes. Raw potato, potato peelings, carrot or lettuce, as well as dried leaves and twigs were used for food. To provide adequate moisture and shelter for the animals, a folded paper towel saturated with water was added. Such containers, when covered with glass, were very satisfactory because they required attention only about once a month or even less frequently. The moisture was easily controlled by wetting the paper towel.

However, during this study, it was necessary to isolate many individuals and to keep them in containers which could be left unattended for a week or longer, and easily transported. Petri dishes containing wet paper, as suggested by Howard and others, were tried, but in our laboratory they did not prove satisfactory. It was difficult to control the humidity in these dishes and they were too small for some of the studies that involved rearing an entire brood in one container.

A plaster cup was finally devised which has proved very satisfactory. The container is 9.5 cm. in outside diameter and 6 cm. in outside height; its bowl is 4 cm. deep and 5.5 cm. in diameter. A groove is cut into the inner margin of the lip, thus allowing a glass cover to fit snugly. These containers were placed in pans of water, and by controlling the depth, the humidity inside the cups could be regulated. The water level in the pans is about the only thing that required attention, and inasmuch as the plaster cups are absorbent, it was not necessary that it remain constant. In fact, the water usually was not replaced until most of it had evaporated.

Periods of Gravidity

Isopods are considered to be gravid when they are carrying eggs, embryos, or young in their marsupia. The period of gravidity, therefore, extends from the time the eggs are first deposited in the marsupium until the young leave it. Inasmuch as the young may quit the brood pouch of their own volition, or the female may break it open and release all the young at once, there is considerable variation in length of time the young remain there. Apparently the young find the opening of the brood pouch only by trial and error; some remain behind as long as a week after the others have left.

Verhoeff (1919) found that for *Porcellio scaber* the period of embryonic development in the marsupium was 35 days, and that the period of larval development there lasted 16 days; that is, the com-

plete gravidity period was 51 days. However, during the present investigation it was found that females of this species were gravid for as short a term as 36 days, while one carried her brood for 57 days. For the 23 females whose periods of gravidity were definitely determined, the average was 43.5 days (Table 10). Usually, it took the second and third broods as long to develop as it did the first. This was not always the case, however, since in one instance the first gravidity period lasted 52 days, and the second only 36 days. All of these females were raised in the laboratory under as uniform conditions as possible.

TABLE 10. Broods of Isopoda Raised in the Laboratory.

Species	Size Range (Lengths in mm.)	Number Young in Brood		Days of Gravidity	
		Range	Average	Range	Average
Armadillidium vulgare	9.5 - 10.5	5 - 53	21	37 - 45	
	11.0 - 12.0	19 - 49	29	37 - 46	
	12.5 - 13.5	5 - 62	37	44 - 51	
Totals	9.5 - 13.5	5 - 62	28	37 - 51	43
Cylisticus convexus	11.0 - 12.0	10 - 30	16	44 - 56	
	12.5 - 13.5	21 - 40	26	48 - 59	
	14.0 - 15.0	16 - 40	28	54 - 62	
	17	30	30	?	
Totals	11.0 - 17.0	10 - 40	24	44 - 62	52
Porcellio scaber	9.5 - 10.5	6 - 37	19	36 - 52	
	11.0 - 12.0	6 - 40	23	36 - 57	
	12.5 - 13.5	17 - 42	40	41 - 46	
	15	40	40	48	
Totals	9.5 - 15.0	6 - 42	24	36 - 57	43.5
Tracheoniscus rathkei	8.0 - 9.0	8 - 15	12	35 - 42	
	9.5 - 10.5	7 - 22	16	36 - 42	
	11.0 - 12.0	7 - 29	17	36 - 42	
	12.5 - 13.5	6 - 25	19	?	
Totals	8.0 - 13.5	6 - 29	17	35 - 42	39

Pierce (1907) found that *Armadillidium vulgare* around Dallas, Texas, had an incubation period varying from 56 to 93 days, and Howard (1940) states that for this species it was between two and three months in England. In Michigan, females of *A. vulgare* raised in the laboratory were observed to carry broods from 37 to 51 days and the average period of gravidity was 43 days (Table 10).

Females of *Cylisticus convexus*, in general, carried broods longer than any of the other species, since they were gravid from 44 to 62 days, averaging 52 days (Table 10). On the other hand, females of *Tracheoniscus rathkei* were gravid for shorter periods than the other species. They carried broods from 35 to 42 days, with an average gravidity period of 39 days (Table 10).

In southern Michigan, gravid females of terrestrial isopods are found out of doors from the middle of March until the early part of August. As would be expected, the period of gravidity for this group living in the northern part of the lower peninsula begins later, around the latter part of May, and usually extends through August. Inasmuch as many females have only one brood per year, the number of gravid females in the first part of the season is greater than at any other time. In the case of *Cylisticus convexus*, which usually has two broods per season, there are two periods in which gravid females are numerous.

Terrestrial isopods collected in the fall and reared in the laboratory have a much earlier period of gravidity than those left under natural conditions. The females usually begin carrying eggs around the first part of December and give birth to young from the latter part of that month through March. If a second mating occurs, females may be gravid as late as the first week of June.

BROODS

Number per Season

Not only is there a difference between the number of broods per season according to species, but for some, the number varies according to locality. For example Vandel (1939) working at Toulouse, France, found that *Armadillidium vulgare* produced three broods a year, whereas Howard (1940) states that the same species had but one brood in England. Eleven of the 18 females of *A. vulgare* raised in the laboratory during the present investigation had only one brood each. On the other hand, four had two broods, two and three broods and one even had four broods.

Twenty-eight females of *Cylisticus convexus* were studied to ascertain the number of broods during a season. Some of these were collected around Ann Arbor in the southern part of the state, others along the shores of Douglas Lake in the northern part of the lower peninsula. Animals taken from the two localities acted approximately alike. Fewer than half of them (12) had two or more broods. One of this group had three broods from one mating, and several others carried eggs in their marsupia for a third time, but these failed to develop. Some of the females from which only one brood left the marsupium carried eggs for a second time during the same season, but these never completed development. In Germany, according to Verhoeff (1919), this species generally has two broods. Females of a population of *Cylisticus convexus* studied in nature at the University of Michigan Biological Station had two periods of gravidity, but there were fewer gravid females during the second period than during the first.

Of the 19 females of *Porcellio scaber* whose broods were studied, ten had only one brood in a season, six had two, and three had three broods. It is usual for this species in central Europe to have three broods per season (Verhoeff 1919). Four of the nine females having at least two broods could not have mated between broods, because they were isolated even from their own young as soon as these left the marsupia. The other five might have mated with their progeny of the first brood, provided these young, from which they were not isolated, could

have become sexually mature within the six months which separated the two broods. Most young reach adult size at five months of age, and may be considered sexually mature. Consequently males of the first brood could have mated with their mothers. It should be pointed out, however, that Howard (1940) has shown that spermatozoa may live in the seminal receptacles of the females for as long as one year, hence, we cannot be sure in these cases of females not isolated from their progeny, whether the second brood was produced by an earlier mating or by mating with one of their offspring. This is one of several problems that will require further research.

Most females of *Tracheoniscus rathkei*, that were isolated when they first became gravid, had only one brood. Only six of them had two broods, and one had three groups of young. In this last case, however, the female could have mated with young of the second brood, from which she was not isolated. In contrast to these findings, Verhoeff (1919) found that in Europe this species usually had two broods per season.

From available data, it appears that in Michigan these isopods when raised in the laboratory have at least one brood per season, and occasionally more. However, *Cylisticus convexus* usually has two broods per season, although some of the second broods never develop beyond the egg-stage. An occasional female of any of the four species may have three broods per season. One female of *Armadillidium vulgare* produced four groups of young from one mating, and therefore had more broods than any of the others.

Number in Brood Pouch

It was feasible to study the number of eggs and other developmental stages in the marsupia of only one of the species under consideration, because the other three did not occur in sufficient numbers at any one time to warrant treating them statistically. Large aggregations of *Cylisticus convexus* were found along the shores of Douglas Lake during the summers of 1941 and 1942. From these, 141 gravid females were studied. Forty were collected July 5, 1941 and the remainder on July 7, 1942. Inasmuch as the number of eggs carried by the females collected in 1941 easily fell within the range of those carried by the 1942 animals, they have been grouped together. Only those isopods whose brood pouches had not been opened and therefore still contained the original number of eggs, embryos or young were considered. Only a few of the many females examined met this requirement, so that a relatively small number of individuals (141) was studied (Table 11). It was not possible to ascertain whether these females were carrying their first or second broods of the season.

The specimens were measured alive, but their broods were examined later after the animals had been killed and preserved. The length of the body was regarded as the distance from the anterior part of the head to the posterior margin of the telson. Width was taken at the widest place—the mid-thoracic region. Roughly, width times length was considered to be the area of the body through the median plane. Measurements were made only to the nearest half millimeter, because the state of contraction of the body segments varied at least that much with individuals.

The eggs, embryos, and young in each marsupium were counted separately. Undeveloped eggs were found rather frequently, although the rest of the eggs in the brood had developed normally. In one instance, over half of the eggs had failed to mature, while the others had reached late embryonic stages when killed. In no instance, however, were eggs, embryos and young all present in one marsupium. The failure of some eggs to develop accounts for the fact that the number of eggs always exceeds or at least equals the number of young produced. The smallest brood consisted of 10 and the largest brood of 70. The second largest brood was composed of 63 individuals, while the third largest was 58. The average number per brood was 33.

The lengths of adult females varied from 10 to 17 mm., and widths ranged from 3 to 7½ mm. The area of body through the median plane for the smallest female was 30 sq. mm., and the corresponding area of the largest one was 119 sq. mm. There were some individuals both in the 1941 and the 1942 groups carrying eggs just beginning to cleave. Others had young ready to leave the brood pouch. However, the majority of isopods studied were carrying developing embryos. This apparently was due to the time of year when the collections were made. Broods of some females, as previously shown, may develop faster than broods of other individuals. More than likely all animals analyzed did not mate at the same time. Therefore, the rate of development of eggs as well as the time of mating of the parents determined the state of the individuals in the marsupia when the females were killed.

The smallest brood (10) was produced by the smallest female (10 x 3 mm.), and the largest brood (70) was from the second largest female (17 x 6.5 mm.). In general, there was a positive relationship between area of body through the median plane and size of brood (Table 11). This is clearly evident in Figures 20 and 21: the former is a correlation table which plots area of body through the median plane of the 141 females in relation to size of their broods, and the latter is the curve derived by grouping these data and plotting the mean. There are slight fluctuations, but this last curve approaches a straight line. The correlation coefficient, + 0.75, between body area and number per brood, indicates that the size of a brood is largely dependent on the size of the female.

In order to contrast the size of an individual brood of a terrestrial isopod with that of an aquatic species, females of *Asellus communis* were obtained from Bar Lake, Manistee County on April 17, 1941. Inasmuch as only 50 females had unopened brood pouches, this study had to be based on a smaller group than was the previous part. Most members of

TABLE 11. *Cylisticus convexus* (De Geer). Number of Eggs, Embryos or Young in Marsupia in Relation to Size of Female.

No. of Indiv. in Group	Size Ranges in mm.			Ranges of Numbers in Marsupia				
	Area of Median Plane	Length	Width	Eggs	Embryos	Young	Total No.	Total Av.
9.....	30 - 39.5	10 - 11	3 - 4	1	13 - 23	10 - 27	10 - 28	19
33.....	40 - 49.5	10 - 12	4 - 4.5	1 - 11	12 - 28	13 - 37	13 - 39	22
20.....	50 - 59.5	12.5 - 14	4 - 4.5	1 - 18	15 - 33	11 - 46	14 - 48	27
12.....	60 - 69.5	11 - 13.5	4.5 - 5.5	1 - 3	15 - 36	46 - 48	15 - 48	29
39.....	70 - 79.5	14 - 15	5 - 5.5	1 - 42	18 - 46	19 - 47	18 - 50	36
8.....	80 - 89.5	14.5 - 16	5 - 6	1 - 44	37 - 50	51	40 - 52	45
15.....	90 - 99.5	14 - 16	6 - 6.5	1 - 52	32 - 54	..	32 - 63	47
3.....	100 - 109.5	16 - 17	6 - 6.5	1	44 - 54	..	44 - 55	50
2.....	110 - 119.5	17	6.5 - 7	3	54 - 70	..	57 - 70	63

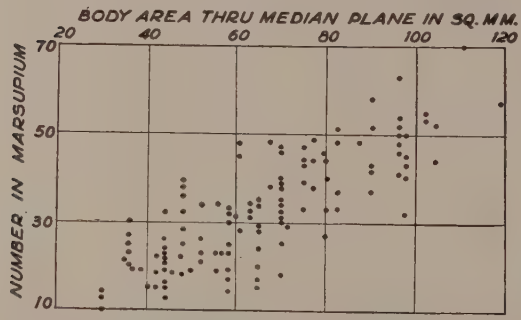


FIG. 20. Correlation table of body area through median plane and number of individuals in marsupium of 141 females of *Cylisticus convexus* collected during the summers of 1941 and 1942 from the shores of Douglas Lake, Michigan.

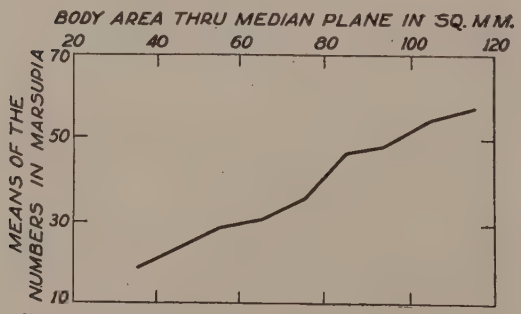


FIG. 21. Curve obtained by grouping data from Fig. 20 and plotting the means.

a brood were in approximately the same developmental stage, but uncleaved eggs were also found. Table 12 groups the lengths of females and the numbers in their broods. Length was measured to the nearest half millimeter, but was taken after the animals had been killed and preserved. Females varied in size from 7 to 11 mm. in length. Broods of *Asellus communis* collected in Michigan were much larger than those of *Cylisticus convexus*. The average brood of the 50 aquatic females was 117. Number per brood ranged from 53 to 235 (Table 12). The 235, however, appears to be an exceptionally large number of young, because the second largest consisted of only 194.

As in the case of *Cylisticus convexus*, the smallest brood of *Asellus communis* was from the smallest female—53 young from an individual 7 mm. long. The largest brood (235) was from a female 10.5

TABLE 12. *Asellus communis* Say. Number of Eggs, Embryos or Young in Marsupia in Relation to Length of Female.

Grouped Lengths (in millimeters)	Number in Group	Ranges of Numbers in Marsupia				
		Eggs	Embryos	Young	Total No.	Total Av.
7 - 7.5.....	3	..	53 - 63	70	53 - 70	62
8 - 8.5.....	4	3 - 146	89 - 98	...	73 - 146	102
9 - 9.5.....	29	1 - 122	72 - 160	90 - 164	73 - 168	117
10 - 10.5.....	12	1 - 235	72 - 168	93 - 133	72 - 235	133
11 - 11.5.....	2	143 - 185	..	..	143 - 185	164

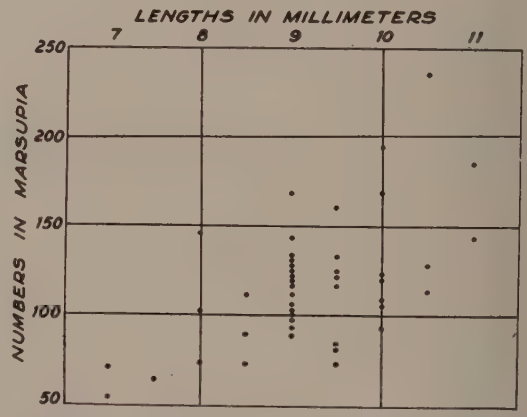


FIG. 22. Correlation table of length and numbers of individuals in marsupia of 50 females of *Asellus communis* collected April 17, 1941 from Bar Lake, Manistee County, Michigan.

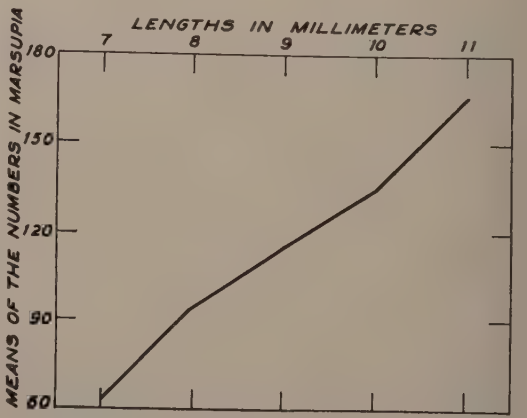


FIG. 23. Curve obtained by grouping data from Fig. 22 and plotting the means.

mm. long. Only two of the 50 females were longer (11 mm.) than this. There is a positive correlation between the length of body and number of young in a brood for this species also (Table 12), the correlation coefficient being + 0.7. Figure 23 is the curve obtained by grouping the data from the correlation table (Fig. 22) and plotting the means of these groups. This curve is almost a straight line, except for slight fluctuations at either end. Therefore, these data indicate a rather close relationship between length of female and number of individuals in her marsupium.

Number of Young That Leave Marsupium

There was a great range in the number of young that left the brood pouch. Not only was there considerable difference in numbers according to species, but large variations existed among individuals of the same species. However, for all Isopoda studied the time of year had no influence on the number of young in a brood.

Pierce (1907) found that *Armadillidium vulgare* around Dallas, Texas, produced from 29 to 79 young per brood. Collinge (1915) reported that individuals of this species from Scotland, raised in captivity, had broods of 50 to 150. He once obtained 267 young from one brood. In France, this species had broods varying from 48 to 156 (Vandel 1939). During the present investigation, it was found that females of *A. vulgare* collected around Ann Arbor had anywhere from 5 to 62 young per brood (Table 10), and the average was 28. When females had two or more broods during one season, the broods usually were approximately equal. The largest number of young (139) borne by a single female during an entire season was from an individual which had four broods. One of the factors which influenced the number of young per brood was the size of the female. For *A. vulgare* a positive correlation with a coefficient of + 0.75 existed between the length of the mother and the number of young she produced in one brood.

The smallest number of young to leave the marsupium of a female of *Cylisticus convexus* was ten (Table 10). One female from Ann Arbor and another collected along the shores of Douglas Lake had broods of this minimum size. Of the 28 females of *C. convexus* which were studied the largest brood was 40, while the average was 24. The number of young produced by a single individual for an entire season ranged as high as 86. Females with broods containing fewer than 15 young usually had other broods during that season.

In a preceding section it was shown that the number of eggs, embryos and young, whatever combinations of these three stages occurred in a marsupium, may range as high as 70 for *C. convexus*. However, the largest number of young actually in a single pouch was 51 (Table 11). Eggs, embryos and young, combined, averaged 33 per brood, while on the average only 24 young left the pouch from a single brood. There is, therefore, a considerable difference between the number of eggs first placed in the marsupium and the number of young to leave it. When the female releases her brood, the undeveloped eggs may be extruded from the marsupium by violent contractions of the body so that the oostegites are forced apart, or, if the female is undisturbed and the young leave the pouch of their own volition, then the undeveloped eggs may remain in the marsupium until the individual molts and they are cast off in the old exuviae.

There was a positive correlation between the length of a female of *Cylisticus convexus* and the number of young in a single brood that leave her marsupium alive. The coefficient for this correlation was + 0.69. In a previous section, it was shown that there was a greater correlation (+ 0.75) than this between the body area through the median plane of females of this species and the number of eggs produced. Failure of all eggs to develop may account for some of the difference between these two coefficients. Another possibility to consider is that length of female alone may not be indicative of the number of young, but that area of body through the median plane based on width as well as length is a better criterion for predicting number of offspring from a single brood.

Collinge (1915) found that females of *Porcellio scaber* raised in the laboratory produced broods of only 12 to 30 young, but in Germany Verhoeff (1919, 1920) recorded broods that averaged 88 individuals. Females of this species in Michigan had broods that ranged from 6 to 42 young (Table 10), and the average was 24. The largest number of young produced by a single female during one season and from only one mating was 89 from a total of three broods. Second and third broods of the season usually had the same number of young as did the first one. However, there were some exceptions to this. A positive correlation, with a coefficient of + 0.71, existed between area of body through the median plane and number of offspring produced in a single brood of *P. scaber*.

According to available data from 28 females, *Tracheoniscus rathkei* had smaller broods than the other three species studied. These isopods also had the shortest periods of gravidity. Broods of *T. rathkei* varied from 6 to 29 young (Table 10), and the average was 17. When one female had more than one brood, usually the number of offspring was about the same for each brood. Two females, both of which mated but once, produced 56 young each during one season. This was the largest number borne by any female of this species during a single season. Although a positive correlation was found to exist between size of female and number of young in a single brood, this correlation was not as significant for this as for the other three species, since the correlation coefficient was only + 0.58.

YOUNG

Females carry not only eggs and developing embryos in their marsupia, but during the last weeks

of gravidity their brood pouches also contain young. The pouch is constructed of five pairs of overlapping plates which extend inward from the bases of the first five pairs of legs (Van Name, 1936). This overlapping of the oostegites allows the marsupium to expand as the developing brood requires more room. When the young are ready to leave the female, the oostegites may barely touch each other, or small gaps may even show between the plates along the mid-ventral line. At this time, the exit from the marsupium first appears as an opening at the anterior edge of the pouch, usually located on the ventral surface of the first thoracic segment. Young of the four species studied become rather active and move around just preceding their departure. In their activity, the young find the anterior opening of the marsupium, or one of the gaps between the oostegites through which they may leave. During the departure of the young the female usually remains relatively quiet. If she is active at all, she moves very slowly, keeping the first pair of legs immobile. The young customarily emerge from the brood pouch head first and climb around on the ventral surface of the female. Most of them descend from their mother by way of her first two pairs of legs. The majority of the young after leaving their parent are not very active and remain together in a group. Towards the end of the emergence period, the female moves away from the young. This time all legs are used, and the motion of the moving female usually forces the few remaining young out of the marsupium. The above is customary when the female is not disturbed. However, if she is agitated while carrying young in her pouch she may, by rhythmical contractions of her body, force apart the pairs of plates forming the marsupium and release all her brood at once. A brood pouch full of young makes it necessary for the female to move around rather slowly and in a humped position; after the release of the brood she assumes her normal position and moves about more quickly.

Pierce (1907) stated that the young of *Armadillidium vulgare* undergo their first molt within 24 hours after leaving the marsupium. During the present investigation this was the case for the great majority of young of this species, as well as those of *Cylisticus convexus, Porcellio scaber,* and *Tracheoniscus rathkei.* However, some molted within 12 hours after they left the female, and others were 64 hours old before they molted the first time. It is only after the first molt that the young become very active. Up to this time they are usually sluggish and tend to remain near the place where they were deposited.

When the young leave the marsupium, they are whitish in color and are somewhat translucent. Soon after their first molt they change to a pale yellow, and from this time on gradually become darker with age. Although young were never found feeding before their first molt, they begin eating shortly after this ecdysis. At this stage in their development they are so translucent that their gut, full of food, is clearly apparent as a dark mid-dorsal line.

Many habits described for the adults are possessed by the young soon after they leave the marsupium. Immature isopods are very gregarious, forming large aggregations. Young of the same size and age usually tend to group together, avoiding the older animals. Young isopods probably are even more cannibalistic than are the older ones. It is not at all unusual to see larger members of a brood feeding upon smaller ones, especially while the latter are molting. Sometimes as many as half of the brood are used for food by the other young. Most of the smaller members of a brood remain runts even if isolated. They seldom attain a length of 5 mm. in a period as long as 30 weeks, so that if they escape their larger brothers in nature they probably never become sexually mature. The ability to roll up into a compact ball is possessed by all young of *Armadillidium vulgare* and *Cylisticus convexus,* even during the day they leave the pouch. Immatures of all four species can feign death as do the adults—ventral side up, legs partially out-stretched, body motionless.

Molting and Growth

The procedure, customarily employed by terrestrial isopods, of molting first the posterior part of the exuviae, followed by shedding the anterior portion, is rather unique and has, therefore, attracted considerable interest (Casserley quoted by Webb, 1900; Pierce, 1907; Aubin, 1914; Mosley, 1915; Verhoeff, 1940). The line separating these body divisions usually is located between the fourth and fifth thoracic segments, but in certain individuals the break may occur between the third and fourth thoracics. However, it was found to be constant for a particular individual.

During the present investigation over 50 broods of four species (*Armadillidium vulgare, Cylisticus convexus, Porcellio scaber,* and *Tracheoniscus rathkei*) were studied to determine the approximate time-interval between the first several molts. These individuals were isolated and were provided with abundant food. As previously stated, the young usually molted for the first time within 24 hours after leaving the marsupium. It was observed that the second molt usually took place within the first two weeks after birth, and that most individuals molted for the third time during the third week. The majority of young underwent the fourth molt during the fifth week, but some were molting as early as the fourth week and others as late as the sixth. Beginning with the fourth instar most of the young underwent a molt every two weeks until they were approximately 20 weeks old. After this period molts were very irregular. The above is not in accordance with Pierce (1907) who found that there was no regularity of molts after the first one; instead, the time of molt was dependent upon the food supply.

Females usually undergo a molt within a few days prior to placing eggs in the marsupium. Probably the oostegites are released by this molt, and form the brood pouch. Shortly after the young leave the pouch the female molts again, forming another

pouch if she is to have another brood. These two molts occur even if the female has not mated, in which case the sterile eggs pass into the marsupium and remain there for as long as a month. However, they begin degenerating within the first week after deposition. When they are shed during the next molt, these eggs are very shriveled and are lumped together into two compact groups, each of which formerly extended the whole length of the marsupium.

Aubin (1914) found that the majority of individuals of *Porcellio laevis* did not hide before molting, but rather remained with the group. This observation, however, is at variance with the data on the four species studied by the present writer. When an adult of any of these species is ready to molt it seeks a protected location on a rough surface. It then becomes rather sluggish and does not feed. A definite break in the exoskeleton occurs in the midthoracic region and the posterior portion of the exuviae appears very loose. Every few seconds the animal contracts its body, thereby gradually pulling out of the exuviae. In the final phases of this half of the molting procedure, the isopod by more violent contractions finally comes out of the posterior portion of the exuviae, usually leaving it in one piece adhering to the substratum. This process may take only 15 minutes, but some animals have been observed to take as long as six hours for it. After molting, the posterior part of the animal is dull, while the anterior half, still covered by the old exoskeleton, is glossy. Usually, at first, the part just molted is narrower than the rest of the body.

A few minutes after the first phase of molting, the isopod begins to move about slowly, using the legs that have not molted. A usual procedure at this time is for the animal to eat its exuviae. However, Aubin (1914) states that individuals of *Porcellio laevis* do not feed upon their cast-off exoskeletons. The isopod remains in seclusion until after the anterior half of the old integument is shed.

Within three days after the posterior molt, the anterior one occurs. Shortly after the animal has devoured the first part of the molted exuviae, the old exoskeleton of the anterior part becomes loose from the body. This time, the animal by slow contractions of the body backs out of the exuviae, which again may be left in one piece. For a while the animal moves only on the legs freed during the first half of the molt, but soon it is using all of them. It usually eats most of the anterior portion of the exuviae before it returns to a group. Approximately a week is required for the entire molting process of an adult, beginning when the individual leaves the group and ending with its return. This period, however, is much shorter for the growing, immature individuals. Many isopods were found dead with the anterior exuviae only partially removed. Others molted, only to die within the next few days.

As previously stated, the first three molts take place a week apart, but beginning with the fourth ecdysis and continuing at least through the eleventh molt, the animals shed their integuments on the average at bi-weekly intervals. A sudden increase of body length may take place after an ecdysis, or the molt may result in only slight increase in size, or even in no growth. During the early weeks of development, regardless of molting, a gradual lengthening of the body occurs. However, in later life an increase in length usually follows a molt, and between molts the animal remains about the same size.

The majority of individuals of all four species studied exhibit certain general tendencies in their development. Many young are approximately 2 mm. long at birth. For most of them a period of rapid and steady growth begins with the first molt. This gradual increase in body size continues until the animal is approximately 8.5 mm. long. Some individuals, however, may not stop their steady growth until they are 10 mm. in length (Fig. 27), and on the other hand animals of minimum size may cease their uniform development when much smaller. Following the period of rapid increase in size, the isopod grows at a slower and somewhat irregular rate. Still later in life, growth generally occurs only with an ecdysis. However, molting does not always result in measurable increase in size.

The curves (Figs. 24-27) showing the rate of growth of the four terrestrial species are based on individuals that lived fifteen weeks or longer. These animals were individually isolated until death, and were measured weekly, beginning with emergence from the marsupium. Some grew very rapidly (Maximum curve, Fig. 26), while others remained stunted. Isopods of this last group, seldom attaining a length of 5 mm., were not considered in drawing the above curves, because in nature they probably do not survive. In order to demonstrate the increase in length during a particular week among individuals of the same species, excluding runts, the extremes in size were plotted as well as the mean length.

Some periods of molting can be noticed in the "staircase effect" in the curves showing increase in lengths of animals of maximum and minimum size. However, times of molting in the early developmental period for *Porcellio scaber* and *Tracheoniscus rathkei* are not as noticeable as are the early ecdyses of *Armadillidium vulgare* and *Cylisticus convexus*. Individuals of *Porcellio scaber* (Fig. 26) had the most uniform rate of development of all the species studied, and *Cylisticus convexus* had the slowest rate of development. Many individuals of *Tracheoniscus rathkei* (Fig. 27), on the other hand, attained most of their growth much earlier than did the individuals of the other species.

The longest life-span reported for any terrestrial isopod is that recorded by Geiser (1934) for *Porcellio laevis*, the males of which, he states, may live as long as five years. Pierce (1907) writes that an individual *Armadillidium vulgare* which he collected "was probably several years old." Howard (1940) records this last species as living at least two years,

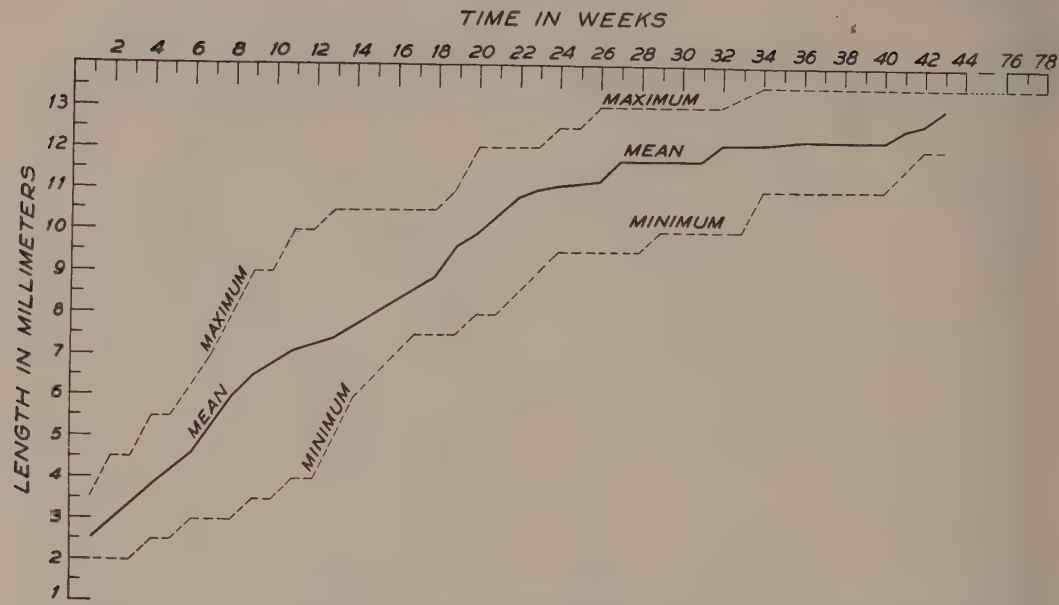

TIME IN WEEKS
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 76 78
LENGTH IN MILLIMETERS
1 2 3 4 5 6 7 8 9 10 11 12 13
MAXIMUM
MEAN
MINIMUM
MAXIMUM
MEAN
MINIMUM

FIG. 24. Increase in length among individuals of *Armadillidium vulgare* (Latreille), showing growth of animals of maximum and minimum size as well as mean growth for all individuals studied.

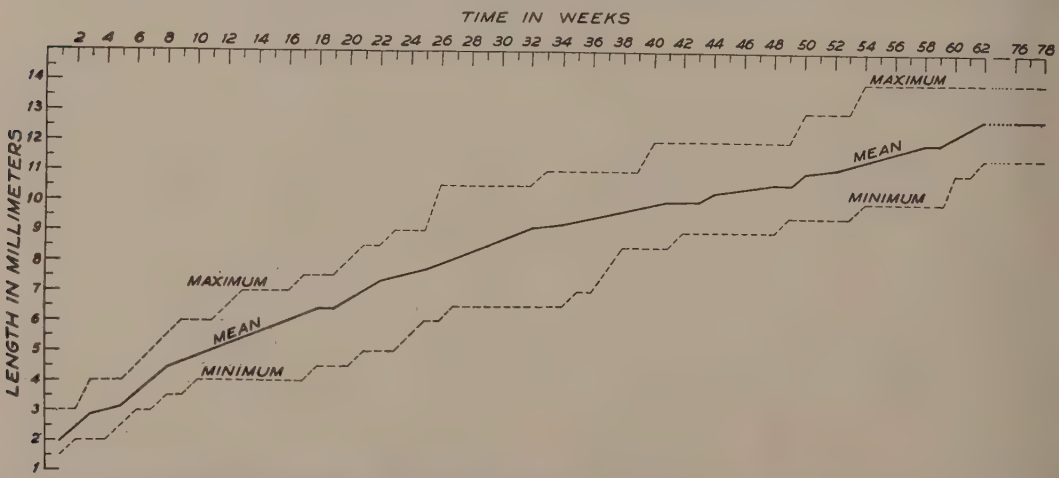


FIG. 25. Increase in length among individuals of *Cylisticus convexus* (De Geer), showing growth of animals of maximum and minimum size as well as mean growth for all individuals studied.

and states that during this period both males and females are sexually potent. Although maximum ages of the four terrestrial species considered in this investigation were not determined, certain data on their longevity were obtained. The present observations ran over a period of three years, but none of the individuals studied survived that long. It appears that isopods raised in the laboratory from females collected in Michigan have a life-span of approximately two years. Howard's (1940) observations in England on *Armadillidium vulgare* are in agreement with this. It was also found that isolated males of all four species lived in the laboratory as long as the females. This is not in accord with the findings of Geiser (1934) who states that members of one sex, depending on the species, may live longer than those of the opposite sex.

AN ISOPOD POPULATION

PREVIOUS STUDIES

The literature dealing with populations of the Oniscoidea is rather limited. There have been two

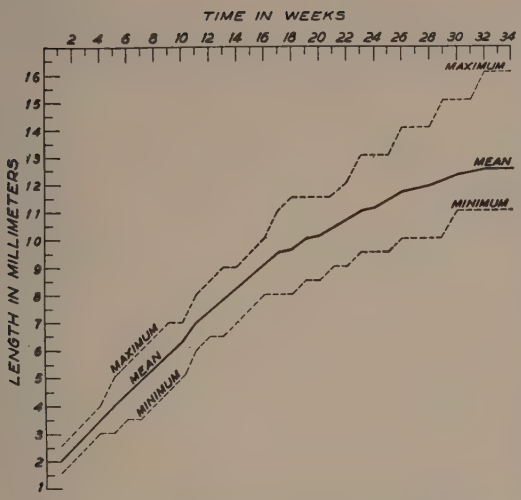

TIME IN WEEKS
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34
LENGTH IN MILLIMETERS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
MAXIMUM
MEAN
MINIMUM
MAXIMUM
MEAN
MINIMUM

FIG. 26. Increase in length among individuals of *Porcellio scaber* Latreille, showing growth of animals of maximum and minimum size as well as mean growth for all individuals studied.

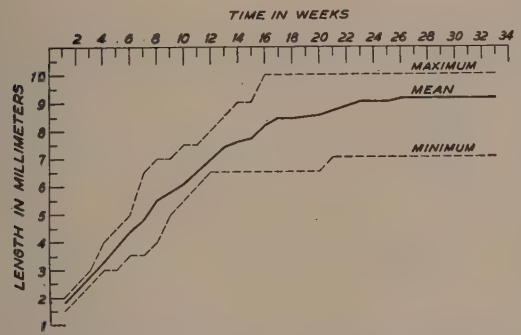


FIG. 27. Increase in length among individuals of *Trachelliniscus rathkei* (Brandt), showing growth of animals of maximum and minimum size as well as mean growth for all individuals studied.

groups of workers interested in isopod populations. One group has studied aggregations of certain species, and from experimental data has obtained explanations of bunching among these animals. The other workers have analyzed populations of various species in order to determine sex-ratios and to interpret differential longevity in relation to sex. Studies of aggregations and distribution according to sex have been, in general, the chief contributions to the analysis of populations of this group of animals.

MATERIALS AND METHODS

The paucity of papers dealing with populations of isopods led the author into this field of endeavor. Sex-ratios of the species selected had not been determined. Nothing was known concerning variations of size in relation to various external factors, nor had periods of gravidity been studied within a large population. These three aspects, therefore, were chosen for emphasis.

On the west shore of South Fish-Tail Bay, Douglas Lake, there stretches a narrow rocky beach along the outer edge of which rise steep wooded slopes. During the summer months, *Cylisticus convexus* occurs in great abundance under stones and driftwood on this beach. These animals do not ascend the slope, but are confined, principally, to the middle beach with an occasional individual to be found in the outer beach. The population of *Cylisticus convexus* occurring in this region was selected for study because individuals of all sizes were abundant in this limited area.

Inasmuch as it was not feasible to study this entire population, various sampling methods were used. Potato traps made according to Geiser (1928) were tried, but proved unsatisfactory because some of them were carried off by mammals and others were filled with spider webs and seldom contained isopods. A square sampler made of sheet metal, each side of which was one half meter long, was devised so that it could be pushed down into the sand; the stones removed from the enclosed area; and the trapped animals picked up. This sampler worked very well along that part of the shore where pebbles and stones were not abundant, but where they were plentiful it was difficult to use. A final method, although somewhat cruder than the use of the sampler, proved more satisfactory. An area of one fourth square meter was marked off on the beach. The stones within this area were carefully removed, beginning at the periphery and working toward the center. In order to escape, the isopods had to cross the cleared spaces and could be picked up easily. Such areas were laid off at five-meter intervals along the length of this particular part of the shore. As soon as the isopods had been removed from a sample area, the rocks and debris were replaced.

Collections were made at weekly intervals during the four summers of 1939 through 1942. No attempt was made to have weekly collections contain the same number of individuals, but rather, each collection was taken from 20 sample areas located in the middle beach. The very young which were unpigmented were not taken since they were indistinguishable from those which were forced from brood pouches when gravid females were crowded into collected bottles. Isopods were gathered before 10 A.M. and were measured during that same day. Subsequently they were killed and preserved in a mixture of nine parts 70% ethyl alcohol and one part glycerine containing a few milliliters of glacial acetic acid.

Length of an individual was measured from the anterior margin of the head to the posterior edge of the telson. The uropods were not included because many of the specimens lacked or were regenerating them. The animals were measured only to the nearest whole millimeter, because contraction and relaxation between segments of the body made more accurate measurement impracticable.

SIZE-FREQUENCIES

Weekly Variations

Histograms were plotted showing the size variations for each weekly collection during the four summers. Since all 33 of these figures showed certain similarities, only those for the summer of 1942 are presented as being typical of this pattern (Figs. 28-37). The great majority of them are bi-modal and for many of these the low point between the two modes occurs at 8.5 millimeters. There is, however, a definite tendency towards the end of each season for these curves to become uni-modal.

During each of the four summers from 1939 through 1942, the population of *Cylisticus convexus* exhibited certain similar phenomena in weekly changes of individual lengths. In the following paragraphs, therefore, the animals collected in 1942 are discussed as showing these typical changes. Weekly variations in size of individuals during that year are discussed later.

In early summer, the population is composed of two groups (Fig. 28). One group is made up of those large individuals that survived the winter; the other consists chiefly of their young born that spring. The older and longer isopods are in the majority during the early summer (Figs. 28, 29), but with the advent of the second brood of the year (Fig. 30) and the dying off of some of the older individuals, the younger group gradually becomes predominant (Figs. 30-33). The young of the first brood grow approximately one half millimeter per week, and it is not surprising, therefore, that longer animals again constitute the larger group (Figs. 34, 35). Toward the end of the season, members of the second brood have increased so much in length that it is no longer possible to distinguish them from others in the population (Figs. 36, 37).

This gradual change in size of animals of the first and second broods, and death of older individuals which survived the winter are clearly illustrated in the histograms. Early in the summer, the curves are broad and distinctly bi-modal (Figs. 28-34). The second mode, representing the older and longer individuals, is, for the most part, larger than the first mode based at first on the young of the first brood plus probably some of the runts that survived the winter, and later upon animals of both the first and second broods of the year. As the weeks pass, the first part of the bi-modal curve becomes predominant (Fig. 33), but in the following weeks, the second mode becomes larger again (Figs. 35, 36). Finally, when the members of the second brood of the season have attained a certain size, the population becomes rather homogeneous and is represented by a narrow uni-modal curve (Fig. 37).

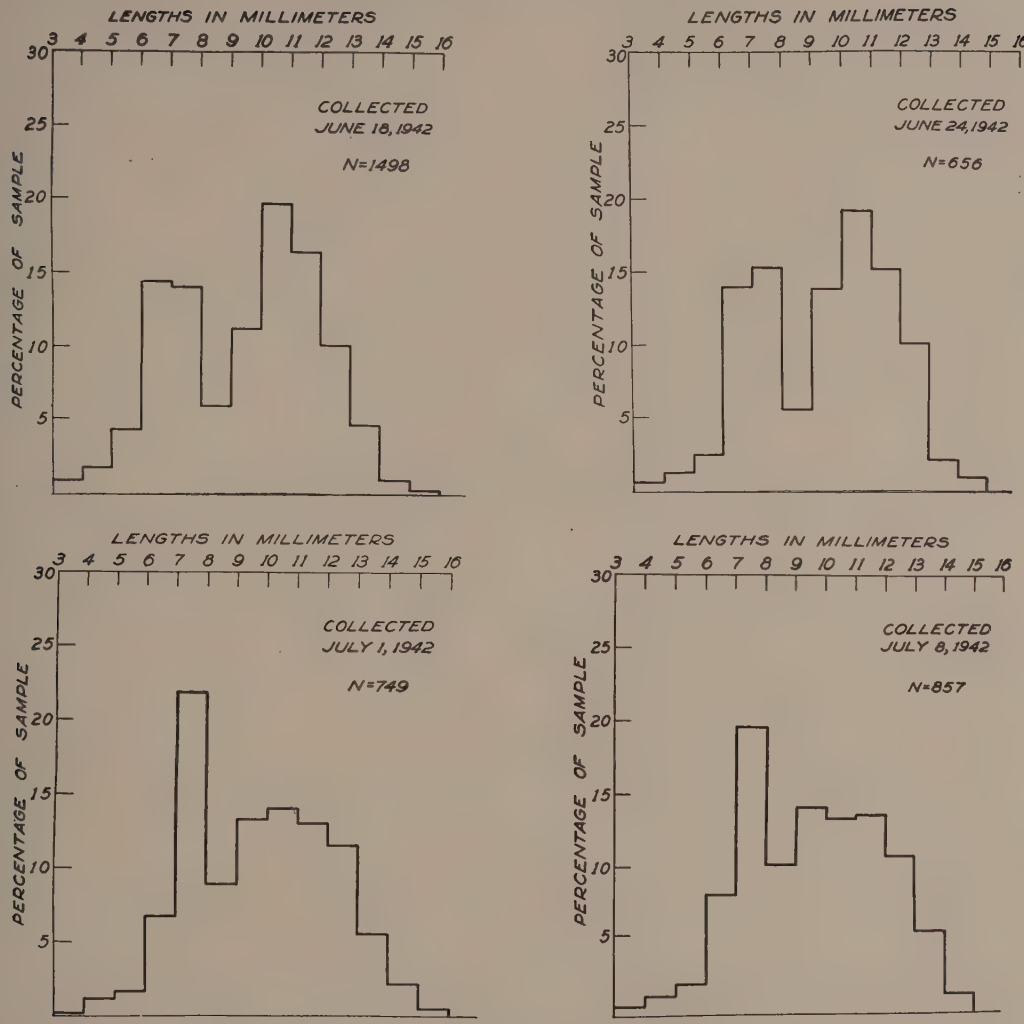
The exact reason why a great many of these bi-modal curves have a low point at 8.5 mm. is not positively known. There is, however, a probable explanation. Only rarely do females of *Cylisticus convexus* in this locality become gravid before they are 8.5 mm. long. In 1941, less than one tenth of one percent of the gravid females were shorter than 8 mm., and during the summer of 1942 the corresponding group comprised only four tenths of one percent. Sexual maturity, then, for the females at least, is not attained until they are over 8 mm. in length. Most individuals raised in the laboratory, regardless of sex, molt after they have become 8 mm. long, and for many an appreciable increase in length follows this molt. Growth up until this time has been rather rapid and steady, but after this length is attained there is a much slower and rather erratic development. The first mode, therefore, of these bi-modal curves represents the immature individuals of the population; the second mode is based on mature specimens. The uni-modal curves which we get at the end of the summer (Fig. 37) show that at this time of the year most of the population has become mature. Runts that never will attain appreciable size are the exception and tend to broaden the curves at their beginnings.

During the summers of 1939 through 1941, weekly variations in lengths of individuals within the population underwent changes similar to those shown for 1942. However, there were certain minor differences. The population of 1939, as illustrated in the weekly samples, definitely consisted of two distinct groups only through July 18. After this date, the two divisions of the population were very difficult to separate. Samples taken in the summer of 1939 did not consist of as many individuals as those of the following years. The irregularity in various size groups may be the result of these smaller samples. The chief difference between the population in 1940 and in 1942 is that the 1940 group became homogeneous after July 24, while the animals in 1942 could be divided into two distinct groups as late as August 12. The variations within the population during 1941 are very similar to those in 1942 which were considered in the previous paragraphs.

A few individuals in this population attained the length of 17 mm. These, however, were rare. On the other hand, most weekly collections contained isopods that were as long as 16 mm. The mean length of the population varied from week to week. During the summer of 1939 the maximum mean length was 10.2 mm., while the minimum mean length was 9.6 mm. In 1940 the mean length of the population ranged as high as 10.5 and as low as 9.8 mm. Mean length in 1941 varied from 10.4 to 8.0 mm., and in 1942 it was between 9.7 and 8.8 mm. This variation, however, is discussed more fully in the following section.

Seasonal Variations

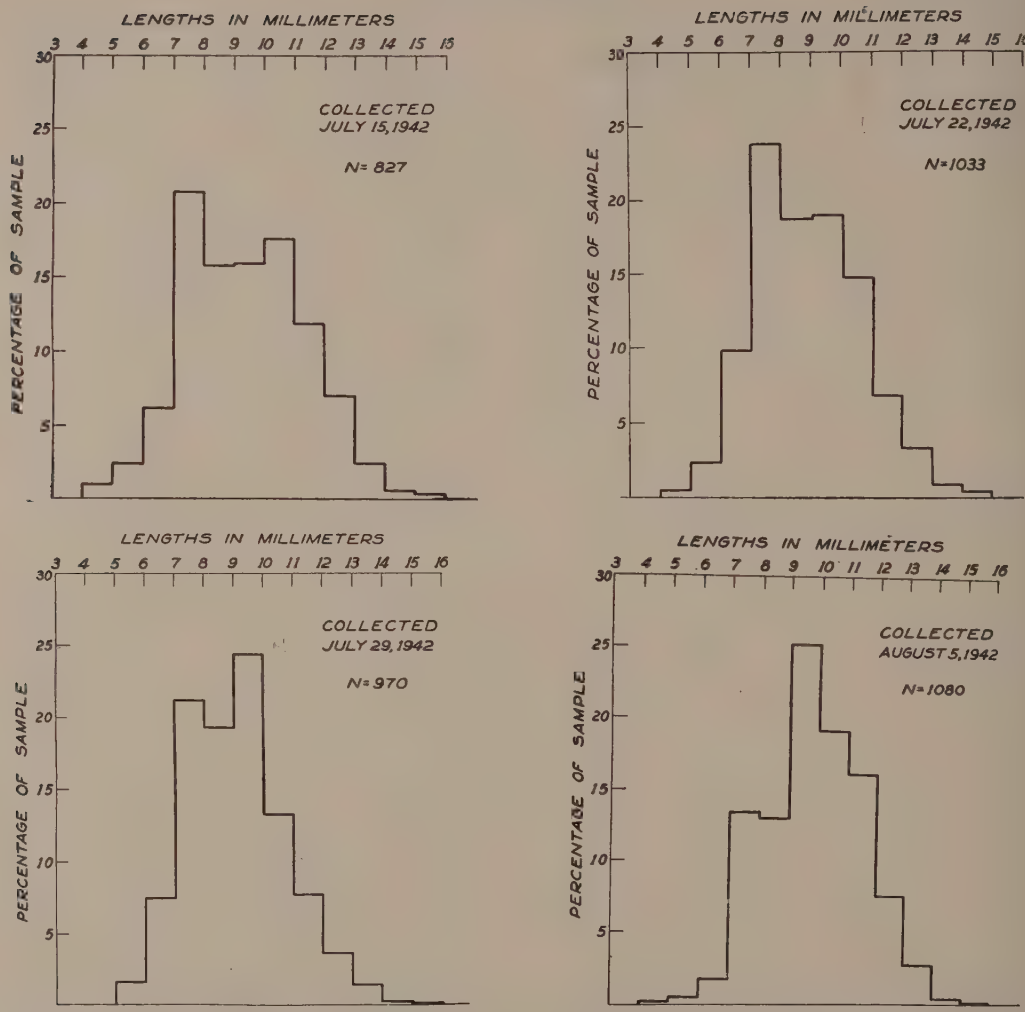
Mean length of the population, based on weekly samples, varied from week to week during the summers of 1939 through 1942 (Fig 38). These fluctuations, however, followed the same pattern for each of the four summers (Figs. 38, 39); the latter curve is based on measurements of approximately 24,000 animals. The mean length of the population increased in the early summer, and reached its maxi-


LENGTHS IN MILLIMETERS
3 4 5 6 7 8 9 10 11 12 13 14 15 16
PERCENTAGE OF SAMPLE
30 25 20 15 10 5
COLLECTED
JUNE 18, 1942
N=1498
LENGTHS IN MILLIMETERS
3 4 5 6 7 8 9 10 11 12 13 14 15 16
PERCENTAGE OF SAMPLE
30 25 20 15 10 5
COLLECTED
JUNE 24, 1942
N=656
LENGTHS IN MILLIMETERS
3 4 5 6 7 8 9 10 11 12 13 14 15 16
PERCENTAGE OF SAMPLE
30 25 20 15 10 5
COLLECTED
JULY 1, 1942
N=749
LENGTHS IN MILLIMETERS
3 4 5 6 7 8 9 10 11 12 13 14 15 16
PERCENTAGE OF SAMPLE
30 25 20 15 10 5
COLLECTED
JULY 8, 1942
N=857

FIGS. 28-31. Size-frequency curves of body length of *Cylisticus convexus* collected during the summer of 1942 along the west shore of South Fish-Tail Bay, Douglas lake, Michigan.

mum between the last week of June and the second week of July. There followed a period of several weeks in which the mean length of the population decreased. This continued until the third or fourth week of July. After this, however, the mean length again increased, but at the end of the summer it began falling once more. Although there is not a great deal of variation in the mean lengths for any one summer, it is significant that similar variations recurred in the other three summers. The differences between the highest and lowest mean length, based on weekly collections, were 0.6, 0.7, 2.4, and 0.9 mm. for the respective summers of 1939 through 1942. Standard errors for the 33 weekly population samples ranged from 0.02 to 0.1 mm.

A possible explanation of this consistent variation during each of the four summers is based on the interaction of at least four factors: the birth and the growth of young on the one hand, the stationary size and the death of older isopods on the other. Previous to the last week of June, 1941, a great many young were born and by the time they were collected in that week, they had grown to a measurable size and therefore greatly influenced the mean length of the population. In other years, this first brood did not appear as early as in 1941, so that its effect upon the size of the population as a whole was not felt until later in the season. During the molt following the release of a brood from the marsupium, many females die. Therefore, the death of the older and longer individuals, as well as the arrival of new broods, tends to lower the mean length

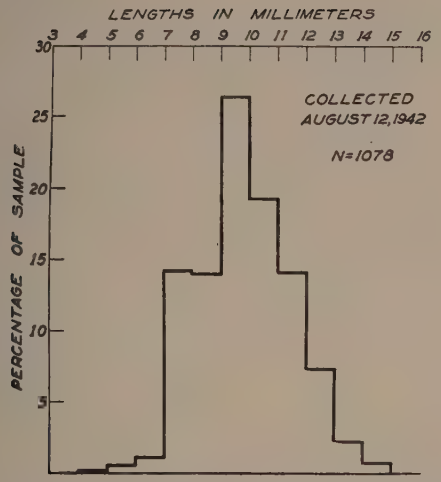

LENGTHS IN MILLIMETERS
3 4 5 6 7 8 9 10 11 12 13 14 15 16
PERCENTAGE OF SAMPLE
30 25 20 15 10 5
COLLECTED JULY 15, 1942
N= 827
LENGTHS IN MILLIMETERS
3 4 5 6 7 8 9 10 11 12 13 14 15 16
PERCENTAGE OF SAMPLE
30 25 20 15 10 5
COLLECTED JULY 22, 1942
N=1033
LENGTHS IN MILLIMETERS
3 4 5 6 7 8 9 10 11 12 13 14 15 16
PERCENTAGE OF SAMPLE
30 25 20 15 10 5
COLLECTED JULY 29, 1942
N=970
LENGTHS IN MILLIMETERS
3 4 5 6 7 8 9 10 11 12 13 14 15 16
PERCENTAGE OF SAMPLE
30 25 20 15 10 5
COLLECTED AUGUST 5, 1942
N=1080

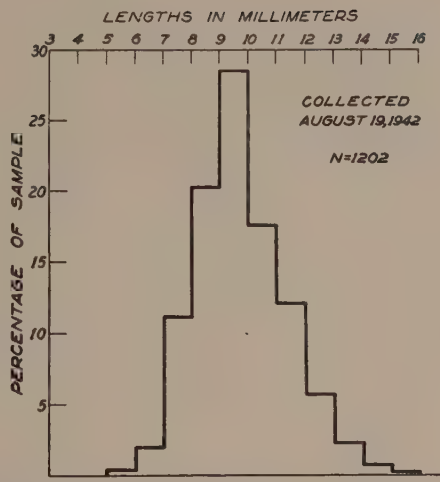
FIGS. 32-35. Size-frequency curves of body length of *Cylisticus convexus* collected during the summer of 1942 along the west shore of South Fish-Tail Bay, Douglas Lake, Michigan (continued).

of the entire population during the first three weeks of July. The young continue to grow, and with their continual growth the mean length of the population increases. During the last weeks of July, however, a second brood appears. Isopods from these second broods are found in the collections of the first week in August, and with their appearance the mean length of the population again decreases.

During early summer when mean length of the population is increasing, the animals fall into two distinct groups, the older and longer of which is predominant (Figs. 28-30). Following this period, however, the mean length decreases, and during these weeks the young and smaller animals are predominant (Figs. 31-33). With an increase of mean length in the succeeding weeks, the longer animals again become outstanding (Figs. 34, 35). The two groups, however, cannot be distinguished easily from one another after the first week in August, when the mean length of the population again decreases (Figs. 36, 37).

Precipitation plays an important part in determining mean length of the population. Data for amount of rain that fell during the summer months when the University of Michigan Biological Station was in session were obtained from Dr. F. C. Gates. The rain gauge was located on the grounds of the Station, near the area within which the isopods were collected. Any effects of local inequalities of precipitation, therefore, were much less than they might have been if the gauge had been located far from the area from which the animals were taken. In summers when little rain fell, the size of most of the individuals was not as great as during rainy summers.





FIGS. 36, 37. Size-frequency curves of body length of *Cylisticus convexus* collected during the summer of 1942 along the west shore of South Fish-Tail Bay, Douglas Lake, Michigan (continued).

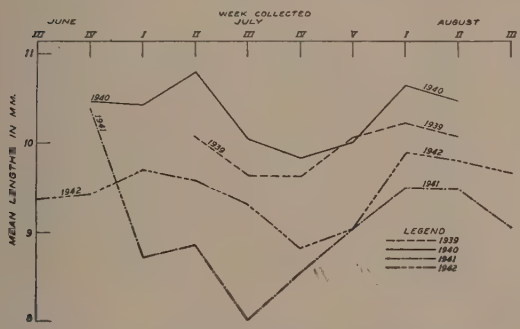


FIG. 38. *Cylisticus convexus*, variations in mean length of body during the summers of 1939-1942.

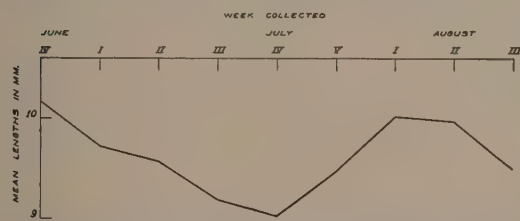


FIG. 39. Typical variations in mean length of body of *Cylisticus convexus* during the summer, based on animals collected at weekly intervals in 1939-1942.

During the summer of 1940 there was 6.18 inches of rain. More rain fell that summer than during any of the other three. It can be noticed from Fig. 38 that for 1940 the mean lengths were greater than for any of the other years. In 1939, 5.81 inches of rain fell, and isopods of that year were only slightly smaller than those of 1940. During 1941 the summer was dry, with only 1.96 inches of rain; correspondingly, individuals of *Cylisticus convexus* were smaller on the average than in the two preceding summers. The summer of 1942 was moderately dry, with 2.34 inches of rain, and isopods taken that summer were somewhat larger than those taken in 1941 but not as long as those collected in the summers of 1939 and 1940 when the precipitation was greater.

Temperature is another factor which undoubtedly influences growth of terrestrial isopods. Unfortunately, it was not possible to isolate it from other interacting factors without conducting experiments over a considerable period, and that did not seem feasible at that time. Temperature curves for each of the four summers were plotted against mean length curves, but it was not evident from these data how changes of temperature affect growth of isopods. In general, however, it can be said that, other things being equal, the effect of increased temperature within a narrow range results in an increase in body length two weeks later. Further study of this particular problem is needed before anything more than the above general statement can be made. Such a study should take into consideration humidity as well as temperature for both the microhabitat and the general environment. The author plans to undertake such an investigation at the earliest opportunity.

SEX RATIOS

The sex of individuals in each size-group of the 19 weekly sample-collections made during the summers of 1941 and 1942 was determined by studying the shape of the pleopods and by the presence or absence of external genitalia. Table 13 gives, for each week of the 1941 and 1942 seasons, the number and percentage of males and females within the various size-groups whose class limits are one millimeter. Distribution of both sexes according to size for each of these two summers, as well as totals for these groups, can be ascertained at a glance.

TABLE 13. *Cylisticus convexus* (De Geer). Size in Relation to Sex.

Summer of	Length in mm.	Number Males	Number Females	Total Number	Percentage Males	Percentage Females
1941....	3 - 4	3	3	6	50.0	50.0
	4 - 5	24	27	51	47.1	52.9
	5 - 6	98	100	198	49.5	50.5
	6 - 7	303	425	728	41.6	58.4
	7 - 8	543	735	1,278	42.5	57.5
	8 - 9	333	510	843	39.5	60.5
	9 - 10	485	704	1,189	40.8	59.2
	10 - 11	327	645	972	33.6	66.4
	11 - 12	172	637	809	21.3	78.7
	12 - 13	50	329	379	13.2	86.8
	13 - 14	13	142	155	8.4	91.6
	14 - 15	1	39	40	2.5	97.5
	15 - 16	0	9	9	0.0	100.0
	16 - 17	1	0	1	100.0	0.0
	Totals....	2,353	4,305	6,658	35.3	64.7
1942....	3 - 4	6	13	19	31.6	68.4
	4 - 5	23	37	60	38.3	61.7
	5 - 6	82	103	185	44.3	55.7
	6 - 7	333	379	712	46.8	53.2
	7 - 8	775	916	1,691	45.8	54.2
	8 - 9	551	744	1,295	42.5	57.5
	9 - 10	802	1,137	1,939	41.4	58.6
	10 - 11	438	1,233	1,671	26.2	73.8
	11 - 12	203	1,081	1,284	15.8	84.2
	12 - 13	63	682	745	8.5	91.5
	13 - 14	13	247	260	5.0	95.0
	14 - 15	1	72	73	1.4	98.6
	15 - 16	0	9	9	0.0	100.0
	Totals....	3,290	6,653	9,943	33.1	66.9

Females of several species of isopods appear to be more numerous than the males. Howard (1940) found in a collection of 380 *Armadillidium vulgare* taken around Cambridge, England, that 273 of them were females and only 107 were males. In other words, over 71% of this group was composed of females. Vandel (1925) also found a preponderance of females for several other species. Geiser (1934), working in Iowa and Texas, found that sexes are approximately equal in collections of *Tracheoniscus rathkei,* but that females are slightly more numerous in *Armadillidium vulgare* and *Porcellio laevis.* According to Geiser, the females of *T. rathkei* have a greater survival value than the males, while the males of *A. vulgare* and *P. laevis* live longer than the females.

During an eight-week period in the summer of 1940 a total of 3,807 individuals of *Cylisticus convexus* was collected along the west shore of South Fish-Tail Bay, Douglas Lake. Approximately 72% of these were females (Table 14). Of the 6,658 specimens gathered during nine weeks of the summer of 1941 nearly 65% were females. From collections made at weekly intervals over ten weeks of the summer of 1942 practically 67% of the 9,943 animals were females. Considering all 20,408 specimens taken during these three summers, slightly more than 67% of them were females (Table 14). In this particular population, therefore, the females were consistently predominant.

TABLE 14. *Cylisticus convexus* (De Geer). Weekly Variations of Sex.

Date Collected Year	Day	Number Males	Number Females	Total Number	Percentage Males	Percentage Females
1940	June 25	111	364	475	23.4	76.6
	July 3	85	364	449	18.9	81.1
	July 12	108	405	513	21.1	78.9
	July 17	157	319	476	33.0	67.0
	July 24	111	209	320	34.7	65.3
	July 31	169	328	497	34.0	66.0
	August 7	139	295	434	32.0	68.0
	August 14	190	455	645	29.5	70.5
1940 Totals.....		1,068	2,739	3,807	28.1	71.9
1941	June 25	423	757	1,180	35.8	64.2
	July 2	208	268	476	43.7	56.3
	July 9	293	807	1,100	26.6	73.4
	July 16	270	450	720	35.8	64.2
	July 23	272	478	750	36.3	63.7
	July 30	178	392	570	31.2	68.8
	August 6	203	446	649	31.2	68.8
	August 13	213	374	587	36.3	63.7
	August 19	293	333	626	46.8	53.2
1941 Totals....		2,353	4,305	6,658	35.3	64.7
1942	June 18	367	1,128	1,495	24.5	75.5
	June 24	223	429	652	34.2	65.8
	July 1	282	467	749	37.7	62.3
	July 8	266	597	863	30.8	69.2
	July 15	237	586	823	28.8	71.2
	July 22	331	695	1,026	32.3	67.7
	July 29	377	596	973	38.7	61.3
	August 5	361	716	1,077	33.5	66.5
	August 12	377	708	1,085	34.7	65.3
	August 19	469	731	1,200	39.1	60.9
1942 Totals....		3,290	6,653	9,943	33.1	66.9
Three Summer Totals		6,711	13,697	20,408	32.9	67.1

The percentage of females varied from week to week during all three summers (Fig. 40; Table 14). Always, however, the females were predominant. Percentage of females in the summer of 1940 varied from 65.3 to 81.1; in 1941, from 53.2 to 73.4; and in 1942, from 70.9 to 75.5. These weekly variations for each of the three summers appear to show a definite trend. The females are most abundant early in the summer. Following this period, the percentage of females in the population continues to drop for several weeks. By the latter part of July, however, the females in the population apparently are increasing again, but at the end of the season they are not as plentiful as they were a few weeks previously. The variation in the percentage of females from week to week appears to be connected with periods of gravidity. A comparison of Figures 40 and 43 shows that shortly after the major period of gravidity early in the summer, when the females are most abundant, there is a decrease in the female population, and a similar decrease occurs again at the completion of the second period of gravidity. Many females of this species raised in the laboratory died during the molt that followed the departure of young from the brood pouch. It would appear that some of the females in this population from

the shores of Douglas Lake also died at the end of their gravidity period, and this would then account for the decrease of females in the sample collections which were made after the two periods of gravidity in nature. The increase in the percentage of females during the middle of the summer probably is the effect of the young from the first brood attaining measurable size. The introduction, therefore, of another group containing more females than males would tend to enlarge again the female population in comparison with that of the males.

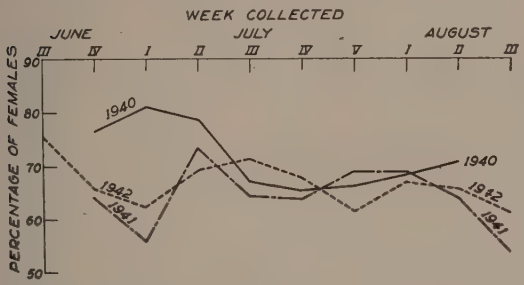


FIG. 40. Variations from week to week of the percentage of females in a population of *Cylisticus convexus* during three summers.

Vandel (1925) and Geiser (1934) state that for various species of terrestrial isopods the sexes are approximately equal in populations of the very young, even though later in life one of the sexes will become predominant. This might also be true for the population of *Cylisticus convexus* under consideration. However, females were generally slightly predominant even in the smallest size-group; the percentage increased with each succeeding group, so that the great majority of the larger individuals were females (Table 13).

According to Vandel (1925) males of many terrestrial isopods are generally smaller than females. He does not give any figures, however, to support this statement, nor does he specify any particular species. In the population of *Cylisticus convexus* studied during the present investigation, the females were consistently larger than the males (Figs. 41, 42; Table 13). The mean length of females at all times during the summers of 1941 and 1942 were greater than the mean lengths of males in this population. This sexual dimorphism was particularly striking each summer until the third week of July, but thereafter there was less difference between the two sexes in this respect.

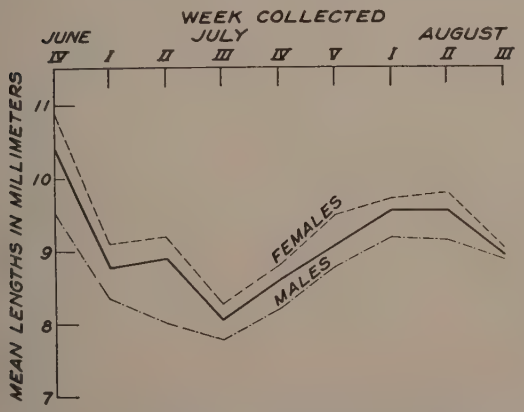


FIG. 41. Variations of mean length of males and females within a population of *Cylisticus convexus* during the summer of 1941.

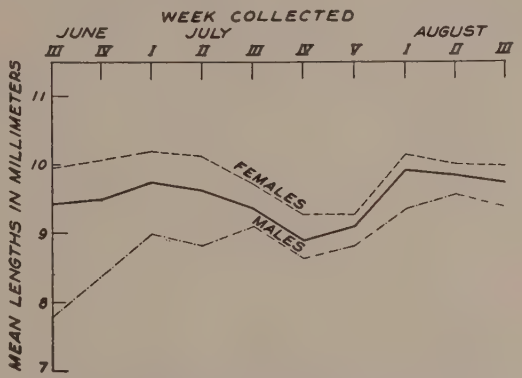


FIG. 42. Variation of mean length of males and females within a population of *Cylisticus convexus* during the summer of 1942.

GRAVIDITY

As mentioned in a previous section, animals were considered to be gravid when they were carrying eggs, embryos or young in their marsupia. Gravid and non-gravid females were separated in each size-group within the 19 collections made during the summers of 1941 and 1942. The numbers and percentages of each group for every weekly collection are listed in Table 15, in which all females collected during each summer are considered together according to the various size-groups. A very few females are mature when 7 mm. in length, but as pointed out previously most reach maturity when between 8 and 9 mm. long, so that it is in this size-group that the first gravid females appear in any significant number when considered as a group for an entire season (Table 15). There was a definite relationship between size of female and gravidity, since as the size of the individuals increased, the percentage in each size-group that were gravid also increased. For example, in 1941, all of the largest females were gravid, and 88.9% of the largest size-group in 1942 were also carrying eggs, embryos or young.

During the last week of June in the summer of 1940, 84% of the females were gravid (Table 16). Starting with the third week of July, however, the young began to leave their mothers, so that between 55 and 56% of the females were gravid on July 17. Finally during the fifth week of July, only slightly more than 14% of all females were carrying eggs or developmental stages in their marsupia. The

TABLE 15. *Cylisticus convexus* (De Geer). Gravidity in Relation to Body Length.

Summer of	Length in mm.	Number Gravid	Number Non-Gravid	Total Number	Percentage Gravid	Percentage Non-Gravid
1941....	3 - 4	0	3	3	0.0	100.0
	4 - 5	0	27	27	0.0	100.0
	5 - 6	0	100	100	0.0	100.0
	6 - 7	0	425	425	0.0	100.0
	7 - 8	1	734	735	0.1	99.9
	8 - 9	39	471	510	7.6	92.4
	9 - 10	118	586	704	16.7	83.2
	10 - 11	181	464	645	28.1	71.9
	11 - 12	316	321	637	49.6	50.4
	12 - 13	243	86	329	73.9	26.1
	13 - 14	119	23	142	83.8	16.2
	14 - 15	38	1	39	97.4	2.6
	15 - 16	9	0	9	100.0	0.0
	Totals....	1,064	3,241	4,305	24.7	75.3
1942....	3 - 4	0	13	13	0.0	100.0
	4 - 5	0	37	37	0.0	100.0
	5 - 6	0	103	103	0.0	100.0
	6 - 7	0	379	379	0.0	100.0
	7 - 8	10	906	916	1.1	98.9
	8 - 9	94	650	744	12.6	87.4
	9 - 10	422	715	1,137	37.1	62.9
	10 - 11	588	645	1,233	47.7	52.3
	11 - 12	633	448	1,081	58.6	41.4
	12 - 13	445	237	682	65.2	34.8
	13 - 14	160	87	247	64.8	35.2
	14 - 15	54	18	72	75.0	25.0
	15 - 16	8	1	9	88.9	11.1
	Totals....	2,415	4,239	6,653	36.3	63.7

TABLE 16. *Cylisticus convexus* (De Geer). Weekly Variations in Gravidity of Females.

Date Collected Year	Day	Number Gravid	Number Non-Gravid	Total Number	Percentage Gravid	Percentage Non-Gravid
1940	June 25	307	57	364	84.3	15.7
	July 3	310	54	364	85.2	14.8
	July 12	335	70	405	82.7	17.3
	July 17	177	142	319	55.5	44.5
	July 24	35	174	209	16.7	83.3
	July 31	47	281	295	14.3	85.7
	August 7	67	228	295	22.7	77.3
	August 14	45	410	455	9.9	90.1
1940 Totals....		1,323	1,416	2,739	48.3	51.7
1941	June 25	589	168	757	77.8	22.2
	July 2	113	155	268	42.3	57.7
	July 9	44	763	807	5.5	94.5
	July 16	13	437	450	2.8	97.2
	July 23	21	457	478	4.4	95.6
	July 30	54	338	392	13.8	86.2
	August 6	46	400	446	10.3	89.7
	August 13	136	238	374	36.4	63.6
	August 19	48	285	333	14.4	85.6
1941 Totals....		1,064	3,241	4,305	24.7	55.3
1942	June 18	789	339	1,128	69.9	30.1
	June 24	296	133	429	69.0	31.0
	July 1	269	198	467	57.6	42.4
	July 8	286	311	597	47.9	52.1
	July 15	61	525	586	10.4	89.6
	July 22	122	573	695	17.6	82.4
	July 29	140	456	596	23.4	76.6
	August 5	176	540	716	24.5	75.5
	August 12	170	538	708	24.0	76.0
	August 19	105	626	731	14.4	85.6
1942 Totals....		2,414	4,239	6,653	36.3	63.7
Three Summer Totals		4,801	8,896	13,697	35.1	64.9

second brood of that year was found in the pouches during the first week of August.

In the last week of June, when the first collection was made during the summer of 1941, practically 78% of all females gathered were gravid (Table 16), but in the following week many broods left their mothers' pouches and only about 42% of the females were carrying broods. Young continued to leave their mothers during the next two weeks, so that on July 16 only approximately 3% of the females collected were gravid, and most of these were in the larger size-groups. After this date, however, the second broods began to appear in the marsupia, so that almost 5% of the females were gravid on July 23. The number of gravid females continued to rise as more and more of them began carrying their second brood for that year, so that on August 13 slightly more than 36% of the females were gravid. In the following week, however, the second brood of young began leaving the marsupia, and only about 14% of the females were gravid.

In the summer of 1942, more of the females (69.9%) were gravid on June 18 than at any other time during that year (Table 16). The number of gravid females remained about the same during the following week (69.0%), but after that many young began leaving the pouches, and on July 1 only 57% of the females were still carrying broods. During the next two weeks most of the young left their mothers, and on July 15 approximately 10% of all females were gravid. Beginning on July 22, however, more females (17.6%) were pregnant with their second broods of the season. In the following weeks the percentage of gravid females increased, but with the departure of young from these second broods, the number of females that were gravid began to decrease.

During these three summers the females of *Cylisticus convexus* became gravid early in June or late in May. Young of 2 mm. in length were found outside brood pouches as early as the second week of June. During the latter part of June and the first weeks of July the great majority of the mature females were gravid (Fig. 43). By the third week of July most of the young had left the brood pouches and only a few females still carried broods. Shortly after this, however, many of the females again became gravid. Not as many of the entire population, however, carried young this second time as earlier in the season. By the first or second week in August these females had deposited their broods, and following this period few females were gravid. Unfortunately the investigation was never continued beyond the third week in August, so that it is not known whether a third brood appeared.

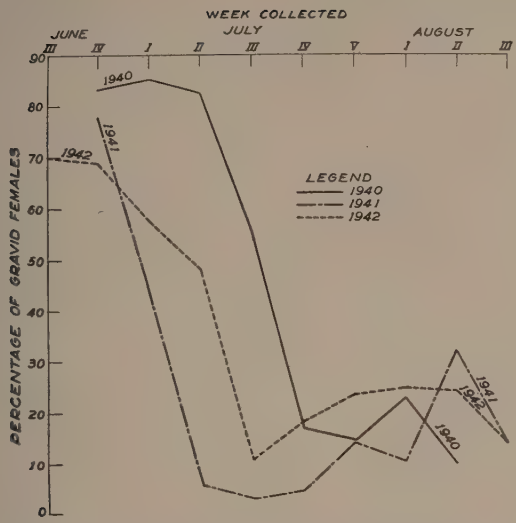


FIG. 43. *Cylisticus convexus,* Curves showing the two periods of gravidity during the three summers of 1940-1942.

Verhoeff (1919) states that in Germany females of *Cylisticus convexus* have their first broods during May and June, and that in July and August the second broods appear. This corresponds rather closely with what is known concerning this species at Douglas Lake, Michigan (Table 16). Many of the females of the population of *C. convexus* from the shores of this lake have two broods during a summer. Young of the first brood appear during the first weeks of July, and the second brood arrives in the latter part of August. These two periods of gravidity are clearly illustrated in Fig. 43, which shows the percentage of females that were gravid each week of the summers of 1940 through 1942. Early in the summer the majority of females are mature, since they were born the previous year and have lived through the winter. Most of them are gravid late in June and early in July (Table 16). By the time the second period of gravidity occurs, young of the first brood have appeared in the collections, and inasmuch as they have not had time to become mature they are not gravid. They tend to decrease, therefore, the percentage of females carrying young during the second period of gravidity. Accordingly, second modes on the curves in Fig. 43 are not as high as they would have been had it been possible to exclude immature females from the collections.

SUMMARY

(1) The objectives of the investigation were to determine which species of isopods occur in Michigan, their distribution within the state, as well as their habitat preferences; to work out as far as possible the salient features of the life histories of four terrestrial species; and to make quantitative analyses of an isopod population in nature with respect to variations in size, sex, and other biological phenomena.

(2) Field work was begun during the summer of 1938 and continued through August 1942. Collecting trips were made into every county of the lower peninsula of the state.

(3) A total of 359 new locality records for isopods was established from 74 of the 83 counties of Michigan. Isopods were collected from all counties of the lower peninsula and in several localities of the upper peninsula.

(4) Fifteen species of isopods representing the suborders Oniscoidea and Asellota are now known to occur in Michigan. Four of these are here reported for the first time from the state. They are *Armadillidium nasatum* Budde-Lund, *Oniscus asellus* Linnaeus, *Trichoniscus demivirgo* Blake for the terrestrial species, and *Mancasellus danielsi* Richardson in the aquatic group.

(5) Check-lists and maps for the various species giving their distribution within Michigan are included. Distribution in the state for each species as it is now known is discussed.

(6) *Tracheoniscus rathkei* (Brandt), *Cylisticus convexus* (De Geer) and *Porcellio scaber* Latreille are generally distributed throughout the state and are the most abundant in the order named. *Oniscus asellus* Linnaeus and *Porcellio spinicornis* Say have been found in few and widely scattered areas in Michigan. *Armadillidium vulgare* (Latreille) occurs principally in the southern part of the state, and *Ligidium longicaudatum* Stoller and *Porcellionides pruinosus* (Brandt) are known in Michigan only from that section. *Armadillidium nasatum* Budde-Lund and *Trichoniscus demivirgo* Blake were collected only in Washtenaw County.

(7) From data now available, it appears that *Armadillidium nasatum* does not occur outside of buildings; *Armadillidium vulgare* is chiefly to be found around human habitations; *Cylisticus convexus* prefers rocky regions; *Ligidium longicaudatum* occurs in wet situations; *Porcellio scaber* lives on beaches, river banks and other moist situations; *Porcellio spinicornis* requires a habitat in which some form of lime is present; *Porcellionides pruinosus* is somewhat urban in its distribution; *Tracheoniscus rathkei,* although generally distributed, is more abundant in deciduous woodlands than elsewhere; and *Trichoniscus demivirgo* prefers moist woodland situations.

(8) A key to the fresh water and terrestrial isopods of Michigan is included.

(9) A method of raising terrestrial isopods in plaster cups is described.

(10) Gravidity periods for four terrestrial isopods were determined. The period for *Armadillidium vulgare* averaged 43 days. For *Cylisticus convexus* it varied from 44 to 62 days, and averaged 53 days. *Porcellio scaber* carried broods for an average of 44 days. Females of *Tracheoniscus rathkei* were gravid on the average for 39 days.

(11) Many females of *Armadillidium vulgare, Cylisticus convexus,* and *Porcellio scaber* have at least two broods a year, while *Tracheoniscus rathkei* females usually reproduce only once.

(12) The number of young, embryos and eggs from the marsupia of 141 gravid females of *Cylisticus convexus* were counted. The smallest brood consisted of 10 individuals, the largest of 70, and the average of 33.

(13) The number of individuals in a brood pouch of *Asellus communis* ranged from 53 to 235. The average brood contained 117.

(14) There is a positive correlation between body size of female and number of young she will produce.

(15) The number of young in broods of *Armadillidium vulgare* raised in the laboratory averaged 28; in broods of *Cylisticus convexus,* 24; of *Porcellio scaber,* 24; and of *Tracheoniscus rathkei,* 17.

(16) The departure of the young from their mother is described in detail. Habits of the very young are discussed.

(17) An isopod molts for the first time within 24 hours after leaving the marsupium. Second and third molts occur during the second and third weeks respectively. Beginning with the fourth instar, molts occur every two weeks until the animal is 20 weeks old. After this age the period between molts is irregular.

(18) Methods and habits of molting, as well as effects of molting on growth, are discussed.

(19) Growth of the four terrestrial species studied was steady and rapid at first, but after the isopod had become approximately 8.5 millimeters in length growth was much slower and somewhat irregular.

(20) It appears that many individuals of the terrestrial species studied may live to be approximately two years old.

(21) A population of *Cylisticus convexus* in nature was analyzed over a period of four summers. Approximately 24,000 individuals were studied.

(22) The population of *C. convexus,* from early summer to the middle of August, consists of two groups: an immature portion born that year, and mature individuals which are over 8.5 millimeters long. After the middle of August most of the population is mature.

(23) Variations in mean lengths of *Cylisticus convexus* for the summers of 1939 through 1942 followed a definite pattern, which may have been the result of death of older individuals and birth of new broods balanced against one another.

(24) The amount of rainfall appears to influence mean growth of the population. During summers when moisture was abundant mean length was greater than in seasons of drought.

(25) The sexes are about equally divided in that part of the population which is smaller than seven millimeters in length. In all other size-groups females are predominant. Sixty-seven percent of all specimens collected during the summers of 1940-1942 were females.

(26) Females of *Cylisticus convexus* in the population studied were longer than the males.

(27) *Cylisticus convexus* has two periods of gravidity. During the first period each summer the majority of females are gravid, but during the second period fewer than half of them carry eggs.

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